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CONCEPT DESIGN
CONCEPT DESIGN ANALYSIS
VOLUME I OF II
HAZARDOUS WASTE CONTAINMENT/CLEANUP
OMC - WAUKEGAN HARBOR
WAUKEGAN, ILLINOIS

Contract No. DACW 45-85-C-0023

Prepared By:

Warzyn Engineering Inc.
Madison, Wisconsin

For:

U.S. Army District
Omaha Corps of Engineers
Omaha, Nebraska

March, 1985

C 11837

WARZYN
ENGINEERING INC

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Engineers & Scientists • Environmental • Geological • Civil • Structural • Geotechnical • Chemical/Materials Testing • Soil Borings • Surveying

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March 8, 1985
C 11837

Mr. Robert Smart
U.S. Army Engineer District
Omaha Corps of Engineers
6014 U.S. Post Office and Court House
Omaha, NE 68102

Re: Outboard Marine Corporation
Waukegan Harbor Superfund Project
Contract No. DACW 45-85-C-0023

Dear Bob:

Herewith, we are submitting the Conceptual Design documents prepared under the subject contract. These documents comprise:

1. Sixty-two drawings as listed on the drawing title sheet.
2. Design analysis including:
   a. General Description
   b. Design Requirements and Provisions
   c. Operations and maintenance provisions
   d. Specification list
   e. Permit requirements
   f. Construction plan
3. Conceptual cost estimate
4. Draft site closure plan
5. Draft site specific safety plan (SSP)
6. Draft site specific quality management plan (SSQMP)
7. Value engineering review report
8. List of unresolved items or criteria

These documents address all of the detailed requirements as set forth in Appendix A of the contract.

On-site validation and extension of existing site data has not been accomplished due to inability to arrange access to the site. The significance of this is related more to detail than to concept and consequently is not of great concern at this time. Resolution of this problem will be needed very shortly as the design progresses into final documents.

Development of these documents working with the Corps of Engineers and the U.S. EPA has been a pleasant and gratifying assignment. We are prepared for and looking forward to your authorization to proceed into final design.

Very truly yours,

WARZYN ENGINEERING INC.

Thomas J. Lynch

Thomas J. Lynch, P.E.
Project Manager

TJL/blc/JCG
[blc-67-5]

cc: David Froh

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VOLUME 1 - Design Analysis

General Description (Part 1)

Design Requirements and Provisions (Part 2)

I Area A, Slip 3, Upper Waukegan Harbor

II Area B, Slip 3, Upper Waukegan Harbor

III Area C, Upper Waukegan Harbor

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V Batch Plant

VI Curing Cells

VII Lagoons

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2. Rates, and % Solids
3. Volume of Soft Sediment
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Site Operations/Maintenance

A. Pipe Routing During Operation

B. Boat Traffic

C. Dredging Control

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IV Water Treatment Plant(s)

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   3. Installation

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1. Location, Length, Width, Depth
2. Volumes
3. Materials and Mixes

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Site Restoration

A. Abandon Temporary Groundwater Monitoring Wells

B. Decontamination of Equipment

C. Final Grading and Pressure Venting

D. Final Cover

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Appendix

VOLUME 1

VOLUME 2

WARZYN ENGINEERING INC

GENERAL DESCRIPTION (PART 1)

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CONCEPT DESIGN ANALYSIS

General Description (Part 1)

A. Purpose

The purpose of this Concept Design Analysis is to compile all engineering criteria, design information and calculations pertaining to the Hazardous Waste Containment/Cleanup project at OMC, Waukegan, IL. This analysis covers deviations from furnished criteria and discusses problem areas that may require changes before the Final Design is completed. This document is for review, approval, or modification before the Final Design is started.

B. Authorization

1. Directives

The extent of the work and basis for design is as defined in the Conceptual Design, OMC Hazardous Waste Site, Waukegan, IL, EPA 13-5M28.0, W65328.00, Sept. 14, 1984. Contract scope of work includes all travel and analysis required to prepare Concept Design Documents for the removal, handling, disposal and containment of polychlorinated biphenyl- contaminated soils from the property of OMC and within the Waukegan Harbor.

2. Scope

1. Authorized Scope/Cost Limitation

Authorized scope of work includes preparation of plans and specifications for the construction/cleanup of the site. In addition, preparation of a SSQMP, a SSSP, and a Final Site Closure Plan are also included. See Appendix C for Design requirements.

The cost limitation is $17,800,000 which includes the total estimated construction cost plus allowances for contingency, supervision, and administration.

2. Design Scope/Cost Estimate

Design activities are as outlined in Appendix A to Contract No. DACW 45-85-C-0023 which is included in Appendix B of this Design Analysis.

The Cost Estimate is a separate entity.

C. Criteria

1. Format of Outline with References & Contract

This Design Analysis is formatted using the "Architect Engineer Instruction Manual for Design of Military Projects". In summary, this analysis is divided into two parts: General Description and Design Requirements & Provisions. Within these sections, the anlaysis is performed by area as follows:

I AREA A, SLIP 3, UPPER HARBOR

II AREA B, SLIP 3, UPPER HARBOR

III AREA C, UPPER HARBOR

IV WATER TREATMENT PLANTS

V BATCH PLANT

VI CURING CELLS

VII LAGOONS

VIII CRESCENT DITCH/OVAL LAGOON CONTAINMENT CELL

IX EAST-WEST PORTION OF THE NORTH DITCH

X PARKING LOT CONTAINMENT CELL

Within each area, material is further divided into four categories: Site Preparation, Site Construction, Site Restoration, and Site Operations & Maintenance. Specific topics are handled within these categories by the applicable disciplines.

2. Provided Criteria

Design Criteria furnished includes items on attached List A. Also furnished to define the scope and character of the project is "Appendix A", Scope of Services For Contract No. DACW 45-84-C-0168. See Appendix A of this Design Analysis for a listing of design references.

3. Items Not Discussed in this Document

Items also submitted but as separate entities include: Site Specific Safety Plan, Site Specific Quality Management Plan, Cost Estimates, Closure Report, and Specifications. These items will be referenced throughout this document.

List A

DESIGN CRITERIA

Preliminary design calculations for North Ditch drainage bypass prepared by Weston Consultants, dated February 1982.

Conceptual Design - OMC Hazardous Waste Site, Waukegan, Illinois, dated June 29, 1984.

Plans and specifications for "Dredging and Water Treatment for Removal of PCB Contamination in Waukegan Harbor", dated June 5, 1981, as prepared by Mason & Hanger-Silas Mason Co., Inc.

Plans and specifications for "Lagoon and Treatment Facility for Removal of PCB Contamination in Waukegan Harbor", Dated June 15, 1981, as prepared by Mason & Hanger-Silas Mason Co., Inc.

Plans showing layout and design of water treatment equipment and dewatering lagoon, dated December 14, 1981, as prepared by Weston Consultants.

Architect Engineer Instruction Manual, dated June 1983.

Omaha District Standard Legend Sheet.

Abbreviations.

Electrical Design Analysis Guide.

Water Line Details.

Sanitary Sewer Details

Technical Manuals for A-E Design Guidance, Master Checklist.

Master List of Specifications Sections.

Sample Civil Works Estimate No. CW-1 & CW-2.

Technical Manuals:

TM 5-813-5	Water Distribution Systems
TM 5-813-6	Water Supply for Fire Protection
TM 5-814-1	Sanitary and Industrial Waste Sewers
TM 5-814-3	Domestic Wastewater Treatment
TM 5-809-1	Load Assumptions for Buildings
TM 5-809-3	Masonry Structural Design for Buildings
TM 5-809-10	Seismic Design for Buildings
TM 5-809-12	Concrete Floor Slabs-on-Grade Subject to Heavy Loads

Specifications for Guidance:

OD 200.02	Removal and Disposition of Equipment and Materials from Existing Buildings

Front End & Non-Technical Specification Data

CE-300.01	Plumbing, General Purpose
CE-303.01	Electrical Work, Interior
CE-303.20 (Int)	Generating Sets, Diesel Electric, Stationary 10-99 KW, with Auxiliaries
CEGS-02110	Demolition
CEGS-02201	Excavation, Filling and Backfilling for Buildings
CEGS-03300	Concrete for Building Construction
CE-16262	Automatic Transfer Switches
CEGS-16263	Diesel-Generator Set, Stationary 100-2500 KW, with Auxiliaries
CEGS-16401	Electrical Distribution System, Aerial
CEGS-16402	Electrical Distribution System, Underground
CEGS-16721	Fire Detection and Alarm System

Appendix "B" to Draft ER 1110-2-246, Guide for Site Specific Quality Management Plan (SSQMP).

ER 385-1-92, Safety and Occupational Health Document Requirements for Hazardous Waste Site Remedial Actions.

Typical Test Hole Data - Soils Investigation

D. Project Description

1. Construction Site

The Outboard Marine Corporation (OMC) site is located on Sea Horse Drive and the west shore of Lake Michigan in Waukegan, Illinois. Polychlorinated biphenyls (PCBs) have been found in Waukegan Harbor & in the North Ditch/Parking Lot Area. OMC outfalls are located in Slip No. 3 & the Crescent Ditch.

Waukegan Harbor was divided into 3 areas of contamination:

Slip No. 3 - PCB concentrations in excess of 500 ppm.

Upper Harbor - PCB concentrations from 50-500 ppm.

Lower Harbor - PCB concentrations from 10-50 ppm.

The North Ditch area includes the Crescent Ditch, Oval Lagoon and the east-west portion of the North Ditch. The levels of contamination are 5,000 - 38,000 ppm, 26,000 ppm, and above 5,000 ppm respectively.

The Parking Lot Area is located north of OMC's Plant No. 2. PCB concentrations are in excess of 5,000 ppm. The southwest corner has concentrations ranging from 50 to 5,000 ppm.

Actions were developed to cleanup and contain the PCB contaminated soils. These actions are briefly described in the next section.

2. Function

The USEPA's cleanup plan consists of 5 actions.

Action 1:

The western portion of Slip No. 3 will be dredged and the contaminated materials will be transported off-site.

Action 2:

The remaining portion of Slip No. 3 & the Upper Harbor will be dredged, Areas B & C respectively. Area B materials will be removed, dewatered, fixed, and disposed of in the Parking Lot Area. Area C sediment will be removed, dewatered, and disposed of in the Parking Lot Area.

Action 3:

Contaminated soil will be excavated from the Crescent Ditch and the Oval Lagoon and will be disposed of off-site.

Action 4:

The east-west portion of the North Ditch will be excavated to install a bypass drainage pipe. The excavated soil will be disposed of in one of the containment cells. The Crescent Ditch/Oval Lagoon area will be enclosed by a slurry wall and capped.

Action 5:

The Parking Lot Area will be enclosed by a slurry wall and will contain contaminated soils. The containment cell will be capped.

A more detailed explanation of these actions can be found in the Conceptual Design, EPA 135M28.0, W65328.00, Sept. 14, 1984.

3. Personnel & Equipment

Construction work on this project has been scheduled to start in the fall of 1985 and to be complete by the end of 1988. This schedule is more fully explained in Appendix M.

On site personnel required for the work will peak at about 80 during the spring of 1986. A work force of less than 30 will be adequate after the summer of 1986.

Major equipment required for the work will comprise:

a) Truck crane: 150-200T: 200' boom with jib.
To be used for piling, clamshell dredging & dispersion control installation in Slip 3 & inner harbor; summer 1986.

b) Hydraulic dredge: 6" discharge: 3,000 gpm.
To be used in Slip 3 & inner harbor: summer 1986.

c) Crawler crane: 100T: 100' boom:
To be used for draglining in Lagoons 1 & 2: intermittent during 1986, 87, and 88.

d) Special backhoe & ancillary equipment:
To be used for slurry wall construction: summer & fall, 1986.

e) 1½-2 yd. backhoe & end loader:

To be used for bypass pipe trenching, Crescent Ditch/ Oval Lagoon excavation & backfilling & for landfill construction: summer & fall, 1986.

f) Bulldozer: D8 or D9:

To be used for landfill construction: Intermittent, 1987 & 1988.

4. Constructability:

The construction procedures planned for this work are all proven systems. There is no reason to expect any constructability problems.

There are special considerations involved in this work which will require some adjustment of normal work routines. Principal among these are:

a) Dredging:

For both clamshell dredging and hydraulic dredging, control of roiling rather than high rate of production is the prime consideration.

b) Lagoon Excavation:

Excavation from Lagoons 1 & 2, expected to be done by dragline, will have to be very carefully controlled to avoid removal of material carrying free water.

Construction specifications for these items will address there considerations.

E. Economic Summary

1. Economic Factors/Considerations:

The value of removal of a pound of PCB from the environment is not computable. The cost is. The total amount of PCB to be removed or contained as a result of this work is 1,083,000 lbs. For the estimated cost of $17,800,000, this amounts to $ $16/lb.

In the North Ditch/Parking Lot Area, approximately 800,000 lbs. of PCB's will be removed or contained at a cost of about $4,000,000; $5/lb.

From the Harbor/Sip No. 3 area, approximately 300,000 lbs. of PCB's will be removed at a cost of about $12,000,000; $40/lb.

The water treatment plants will remove about 200 lbs. of PCB at a cost of about $2,000,000; $10,000/lb.

2. Value Engineering Review:

A Value Engineering Review was performed. The items suggested therein for further study have been addressed in this Design Analysis. The Value Engineering Review is contained in Appendix P.

Design Staff

The following individuals participated in the design and checking of the Design Analysis, Associated Reports and Drawings. Initials of the appropriate personnel are located on each sheet.

Warzyn Engineering Inc.
Madison, WI

Initial	Name	Discipline
TJL	Tom Lynch	Civil
WW	William Wuellner	Geotechnical
RHW	Rich Weber	Geotechnical
MNS	Michael Schultz	Geotechnical
RAJ	Robert Jones	Structural
KAN	Ken Nickels	Structural
DJD	Doug Dahlberg	Civil
LAB	Leslie Busse	Civil
DLF	Dennis Fredrick	Senior Technician
FAM	Fred MacDonald	Technician

Donohue and Associates, Inc.
Sheboygan, WI

SCS	Scott Solverson	Civil
BVR	Blaine Robinson	Civil
TRJ	Terry Johnson	Civil
DDP	Dennis Dineen	Process Design
MLJ	Michael Johst	Process Technician
AGS	Andy Savina	Process Technician
TS	Tom Suszek	Water Treatment and Design
KP	Kurt Peterson	Technician
GC	Greg Cobourn	DSSQMP/Sampling and Testing

WARZYN ENGINEERING INC

Initial	Name	Discipline
KS	Ken Snell	Volatilization Control
LT	Loren Trick	Chemist
DK	Dick Kruger	Instrumentation and Controls
NC	Neil Chambers	Electrical Construction Costs
JM	John Miracle	Electrical
RP	Rich Piette	Structural Cost Estimate
HJ	Harvey Johnson	Structural

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DESIGN REQUIREMENTS AND
PROVISIONS (PART 2)

WARZYN
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I AREA A, SLIP 3, UPPER WAUKEGAN HARBOR

WARZYN
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SITE PREPARATION

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RAJ DATE 2-12-85 SUBJECT HAZARDOUS WASTE SHEET NO. I-1 OF
CHKD. BY Tom--- DATE 2-27-85 CONTAINMENT / CLEANUP JOB NO. 11237
OMC / WAUKEGAN HARBOR

A Removal of Existing Site Features

1. Removal of Walkways and Finger Piers

To facilitate dredging operations and other activities occurring in slip No. 3 existing floating and fixed piers and related support piling, owned by Larsen Marine, shall be removed where they intefere with work. All items removed shall be decontaminated and temporarily stored on site within the construction limits.

4 sections of pier and 17 steel piles shall be removed

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I. Area A, Slip 3, Upper Waukegan Harbor

Site Preparation

B.1 Utilities - Electrical

1. Electrical service to the site is available from Commonweath Edison's existing power distribution system presently serving the Larsen Marine facility.

2. A separately metered, 120/240 volt, singe phase, three wire electric service will be located near the decontamination station to provide power for a steam generator. This electric service will also provide power for the security control station, hopper agitator, and area lighting.

3. The decontamination and hopper areas will be illuminated to provide minimal general work area lighting. The security station will be illuminated to provide minimal security lighting. These areas will be illuminated using 150 watt HPS street lighting type luminaires with integral photo controls mounted on wood poles.

MABS/BK2

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I. Area A, Slip 3, Upper Waukegan Harbor

Site Preparation

B. Utilities - Additions and Modifications

1. Electrical power will be required for an auger or vibration device at the dredging loading hopper.

2. Water will be pumped from within the cofferdam during times when the clamshell dredge is not operating. The water will be pumped to Lagoon No. 1. The pump will be a portable type pump with capacity of 500 gpm. Piping will be routed through the Larsen Marine property or will be hung along the side of the harbor piling. The pump will be gasoline powered.

C. SITE DRAINAGE

C.1 Transportation Route
Trucks will be loaded with clamshell dredging at a site adjacent to the clamshell dredge. The trucks will exit the west gate of Larsen Marine. The entire loading and transportation site within Larsen Marine property will be curbed and drained back to the Slip 3 cofferdam area.

MABS/BOO

DRAFT

SITE PREPARATION

I AREA A

C. SITE DRAINAGE

2. LOADING/HOPPER AREA

The truck loading and hopper area located as shown on Sheet No. 032 is to be constructed so that any spillage will drain back into the harbor to prevent dispersal of contaminants. Any solids spilled should be cleaned up and added to truck load

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SITE PREPARATION

I AREA A

D. FENCING

Approximately 65' of security fencing is necessary in this area See Sheet No. 032 for location. A gate will also be installed to accommodate truck routing. This fencing is in addition to the existing fence. Fencing is to be 6 foot high chain link.

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SITE CONSTRUCTION

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WARZYN

I. Area A Slip 3, Upper Waukegan Harbor

Site Construction

A.1 Decontamination Station

A decontamination station will be located near the cofferdam dredging area in Slip 3. This station will be designed to handle all transport vehicle traffic as well as dredging equipment and personnel. All traffic leaving the cofferdam area will be required to pass through this station prior to leaving the site. The station will consist of a concrete pad overlain by a steel grating and enclosed with a small dike or curb. Grating is necessary in order to reduce contaminant transport via truck tires. The entire decontamination pad should be sloped into a single catch basin area where wash fluids can be drained back to the cofferdam or piped to Lagoon No. 1. It is anticipated that decontamination of equipment, other than the transport trucks, will also take place at this station. Therefore, runoff of washing fluids back into Slip 3 during final decontamination activities should not be allowed. A personnel decontamination station, with associated emergency equipment, will be located adjacent to the vehicle decontamination area.

The decontamination area will have security lighting. The contractor will have the option of providing additional lighting in the event he chooses to work at night. The decontamination station will also require a source of pressurized, clean water and electrical service.

The facility will be located near the west gate of Larsen Marine.

MABS/B01

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I. Area A, Slip 3, Upper Waukegan Harbor

Site Construction

A.2 Decontamination Facility

A concrete collection pad with trench drains is being considered to facilitate the washdown of hauling trucks and other equipment used in handling the contaminated material. The overall decontamination facility containment area is expected to be approximately 60 feet by 12 feet and 8 inches thick. The final dimensions for the containment area are dependent on the amount of water used in washdown, number of vehicles requiring washdown, and frequency of the emptying of the tank.

MABS/BJ5

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SITE CONSTRUCTION

I AREA A

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B. CLAMSHELL DREDGING

Clamshell dredging will be done to remove the deep contaminated sand and silt and the soft sediment within the cofferdam area. A clamshell dredge is being used due to space limitations

1. Volume of Soft Sediment

The volume to be removed is 1,441 cy. This material has PCB concentrations that exceed 10,000 ppm.
For volume generation and computer listing, see Appendix D, Computer Analysis - Dredging Volumes

2. Volume of Sand & Silt

The volume of sand & silt to be removed from the area is 3,923 cy. See p56 of Cofferdam Design for volume computation.

3. Clam Type, Size and Rate

For dredging of the soft sediment a closed bucket with an approximate capacity of 1½ cy will be used to minimize spillages.

Because a closed bucket could not bite into the hard sand and silt, a regular bucket with an approximate capacity of 1½ - 3 cy will be used for the deep contaminated sand & silt

4. Crane Location

The crane will be located as shown on Sheet No. 032. This location makes it possible to dredge the entire area that needs to be clamshell dredged from one position

DRAFT

5. Control

During dredging, extreme care must be taken to minimize spillage. It should be understood that the process will be a slow and methodically-executed activity.

Since dredging to a particular depth is to be completed, there should be devised a way in which to recognize that depth when attained.

Horizontal control should also be considered with regard to the area of deep contaminated material.

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BY ROBERT A JONES DATE 12-19-84 SUBJECT Hazardous Waste Containment/Cleanup OMC/Waukegan Harbor Waukegan, ILLINOIS

CHKD. BY KEN DATE 3/4/85 A. Hickey

SHEET NO. 1 OF 53
JOB NO. 11837

DRAFT

AREA A

C. ACTION No. 1 - CIRCULAR COFFERDAM DESIGN

1. The cofferdam design is an original design.

2. Design criteria references:

   a. AISC Steel Construction Manual - 8th Edition

   b. USS Steel Sheet Piling Design Manual

   c. Nav Fac DM 7

   d. Foundation Analysis & Design - Bowles

3. Structural design loads and conditions

   a. Critical loading condition occurs along that portion of the cofferdam inland from the present slip No. 3 bulkhead.

   b. Assumptions:

      1) Top of cofferdam wall elev. = 584

      2) Finished grade elevation = 583

      3) Water elevation outside cofferdam = 582

      4) Water elevation inside cofferdam = 579

      5) Dredge line elevation = 556; Allows for 1' overdredge

c. Refer to KHW Calculations located at the end of this section for determination of soil parameters.

$\phi_{sand} = 35°$

$\gamma_{sand} = 120$ PCF

$\gamma_{sand\ sub.} = 58$ PCF

$K_{a_{clay}} = 1.0$

$K_{p_{clay}} = 1.0$

$C_{clay} = 4000$ PSF

$\gamma_{water} = 62.5$ PCF

NOTE: PRELIMINARY SUBSURFACE INVESTIGATION IS NOT COMPLETE AT THIS TIME.

$\gamma_{clay} = 135$ PCF

$\gamma_{clay\ sub.} = 73$ PCF

d. Seismic design considerations are not applicable for this design because of the location being one of low intensity and frequency and the temporary nature of the structure.

4. Steel walers, shapes and plates: ASTM A36; $F_y = 36^{ksi}$
These structural steel shapes will be used for bracing the walls of the cofferdam.

Steel Sheet Pile: ASTM A328, $F_y = 38.5^{ksi}$
The sheet pile will be used as the wall of the cofferdam.

5. Description of the Structural System -

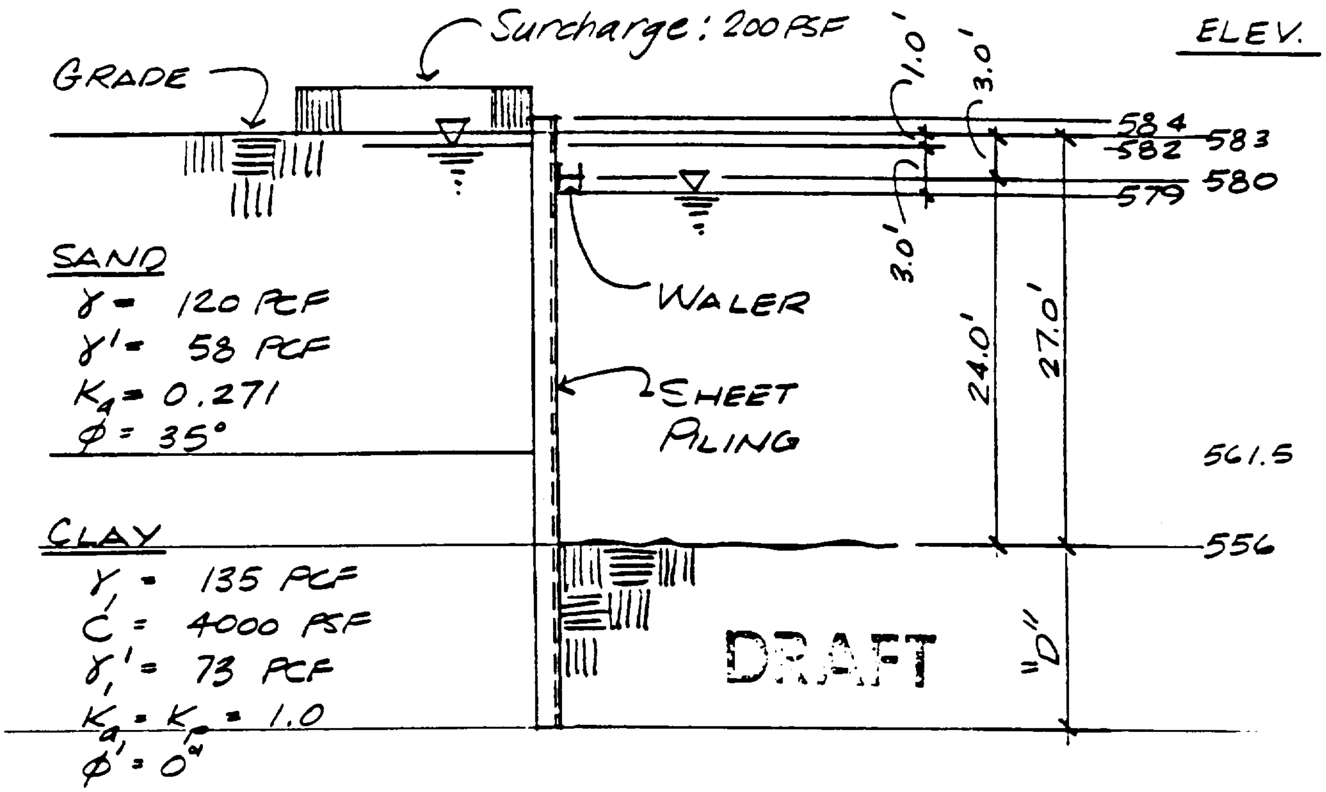
The cofferdam is comprised of steel sheet pile walls encompassing an 85 Ft. diameter area and a height of approximately 25 Ft. The cofferdam walls will be internally braced with structural steel rolled shape walers.

6. There are no miscellaneous design features

7. There is no site adaptation of a standard or existing design.

8. STRUCTURAL COMPUTATIONS -

Utilize the "EQUIVALENT BEAM METHOD"① FOR DESIGN



γ = Unit weight (PCF) ϕ = angle of repose

γ' = Submerged unit weight (PCF)

C = Cohesion (PSF)

K_a = Active earth pressure coefficient = $\frac{1-\sin\phi}{1+\sin\phi}$ (no units)

K_p = Passive earth pressure coefficient = $\frac{1+\sin\phi}{1-\sin\phi}$ (no units)

① USS Steel Sheet Pile Design Manual

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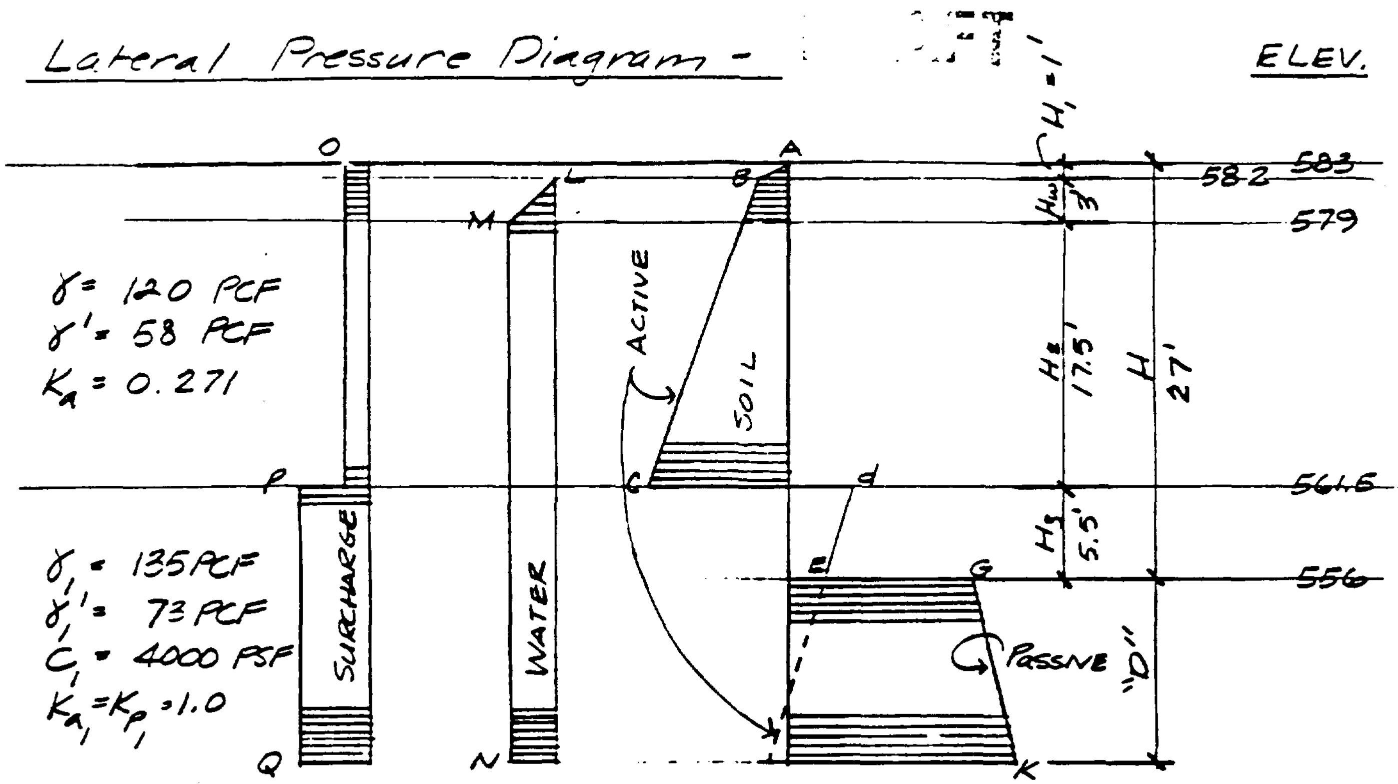
BY RAJ DATE 12-20-84 SUBJECT Action 2- Cofferdam Design OMC/Waukegan Harbor SHEET NO. 4 OF 53
CHKD. BY KAD DATE 3/4/85 JOB NO. 11837

Lateral Pressure Diagram -



Calculate Lateral Pressures @ Locations of Change -

$P_b = \gamma H_1 K_a = 120 \times 1 \times 0.271 = 33$ PSF

$P_c = P_b + \gamma'(H_2 + H_w) K_a = 33 + 58(17.5+3) \times .271 = 355$ PSF

$P_D = \Sigma \gamma H - 2C = \gamma H_1 + \gamma'(H_w + H_2) - 2C =$
$120 \times 1 + 58(17.5+3) - 2 \times 4000 = -6691$ PSF

$P_E = \Sigma \gamma H - 2C = P_D + \gamma_1' H_3 = -6691 + 5.5 \times 73 = -6289$ PSF

Unsupported clay height $= \frac{2C}{\gamma'} = \frac{2 \times 4000}{73} = 109.6'$

Because the saturated clay is capable of such a high vertical unsupported cut; by inspection there will be no active earth pressure exerted on the sheet pile wall in the clay zone.

$P_G = 2C = 2 \times 4000 = 8000$ PSF

$P_K = \Sigma \gamma H + 2C = \gamma_1' D + 2C = 73D + 2 \times 4000 = 73D + 8000$

$P_L = 0$

$P_m = \gamma_w H_w = 62.5 \times 3 = 188$ PSF

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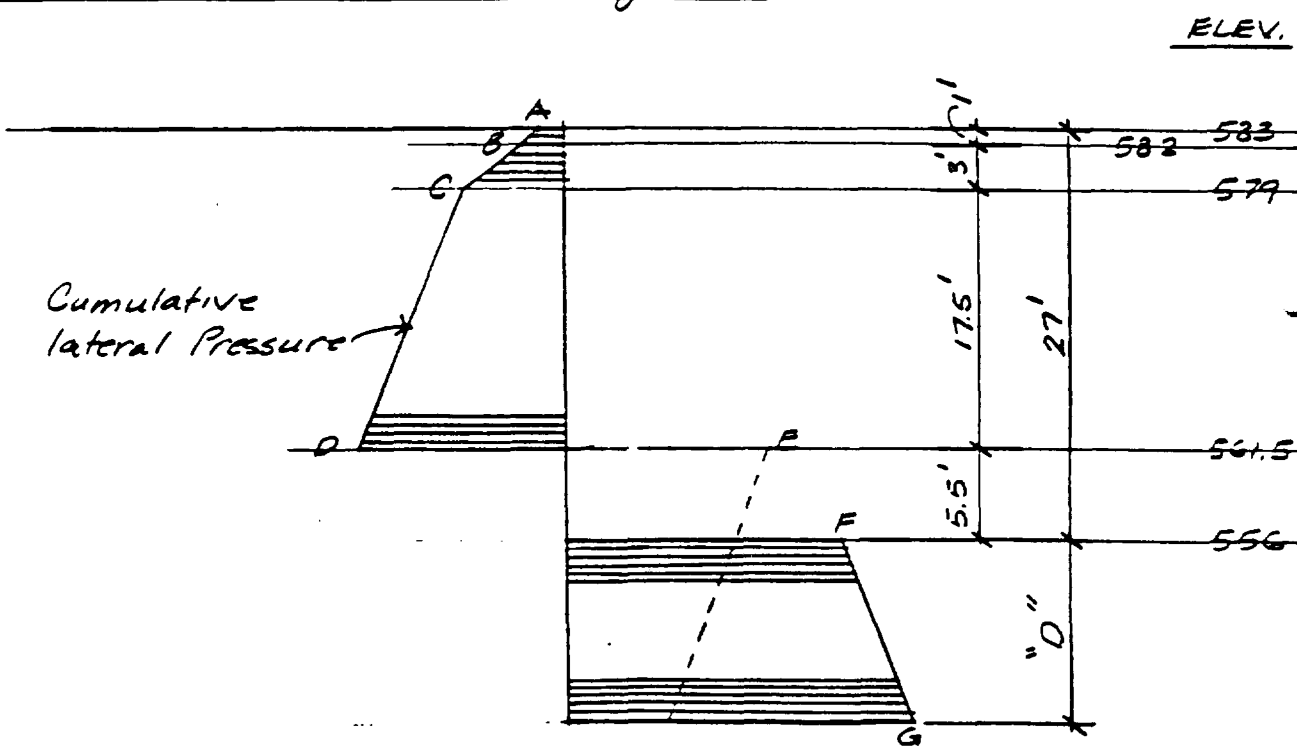
$P_n = P_m = 188$ PSF

$P_o = K_a \times$ Surcharge $= 0.271 \times 200 = 54$ PSF

$P_p = K_{a_1} \times$ Surcharge $= 1.0 \times 200 = 200$ PSF

$P_g = P_p = 200$ PSF

Final Lateral Pressure Diagram -



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$P_A = P_a + P_o = 0 + 54 = 54$ PSF

$P_B = P_b + P_1 + P_o = 33 + 0 + 54 = 87$ PSF

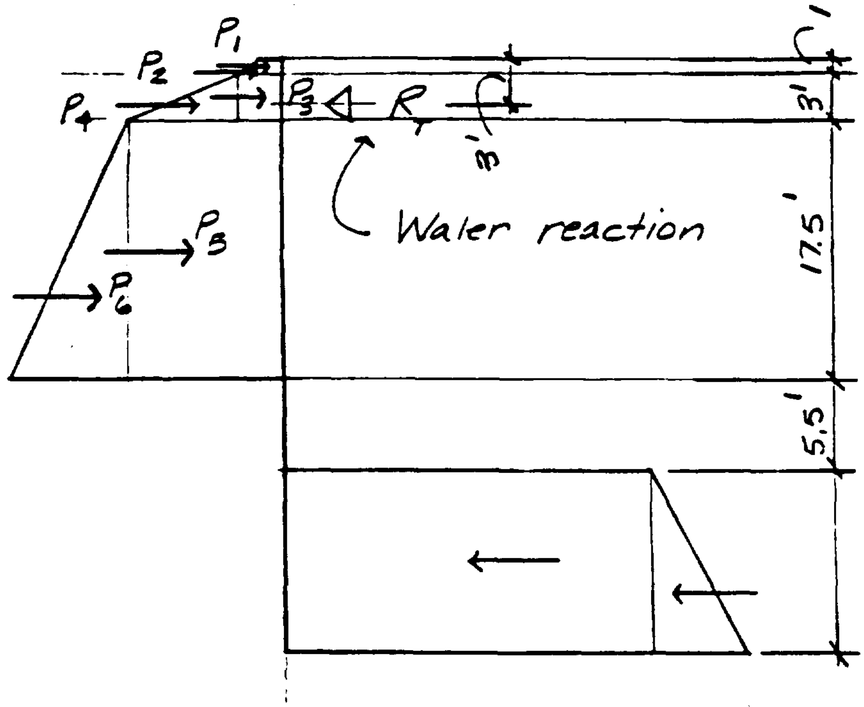
$P_C = P_m + P_o + P_b + \gamma' H_w K_a = 188 + 54 + 33 + 58 \times 3 \times .271$
$= 322$ PSF

$P_D = P_c + P_m + P_o = 355 + 188 + 54 = 597$ PSF

$P_F = P_J = 8000$ PSF

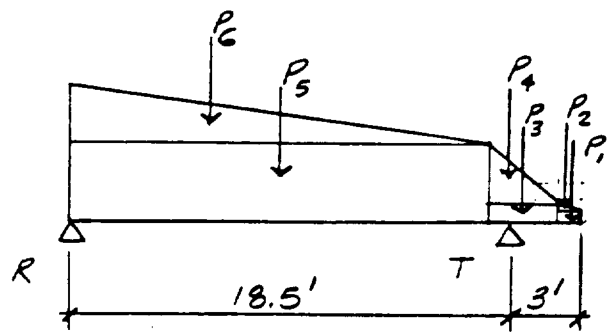
$P_G = P_k = 8000 + 730$ PSF

RESULTANT PRESSURE DISTRIBUTION



Point of zero pressure occurs @ Sand/Clay interface. Assume point of Contraflexure is at point of zero pressure.

Equivalent Beam -



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$P_1 = P_A \times 1 = 54$ #/FT

$P_2 = (P_B - P_A) \times 1 \times 1/2 = (87-54) \times 1/2 = 17$ #/FT

$P_3 = P_B \times 3 = 87 \times 3 = 261$ #/FT

$P_4 = (P_C - P_B) \times 3 \times 1/2 = (322-87) \times 1.5 = 353$ #/FT

$P_5 = P_C \times 17.5 = 322 \times 17.5 = 5635$ #/FT

$P_6 = (P_D - P_C) \times 17.5 \times 1/2 = (597-322) \times 17.5 \times 1/2 = 2406$ #/FT

Solve for "T" ; $\Sigma M @ R = 0$

$\therefore P_6 \times 17.5 \times 1/3 + P_5 \times 17.5 \times 1/2 + P_4 \times 18.5 + P_3 \times 19 + P_2 \times 20.833$

$+ P_1 \times 21.0 - T \times 18.5 = 0$

$2406 \times 5.833 + 5635 \times 8.75 + 353 \times 18.5 + 261 \times 19 + 17 \times 20.833$

$+ 54 \times 21.0 - T \times 18.5 = 0$; $\therefore T = 4125$ #/FT ; Solve for "R"

$\Sigma F_V = 0$; $P_1 + P_2 + P_3 + P_4 + P_5 + P_6 - T - R = 0$

$\therefore R = 54 + 17 + 261 + 353 + 5635 + 2406 - 4125$

$= 4601$ #/FT

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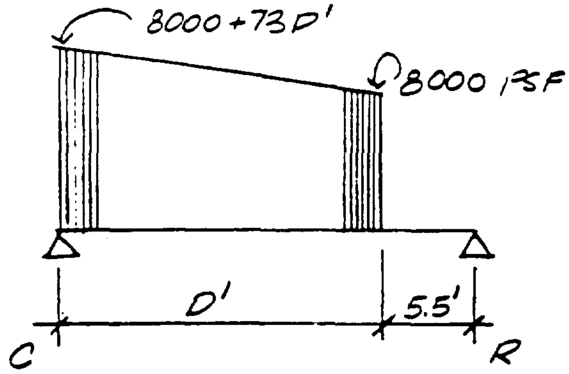

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Calculate D' ; $\Sigma M @ C = 0$

$8000 D' \times D' \times 1/2 + (73D')D' \times 1/2 \times D' \times 1/3 - R \times (D' + 5.5) = 0$

$4000 (D')^2 + 12.17 (D')^3 - 4601 D' - 25306 = 0$

$12.17 (D')^3 + 4000 (D')^2 - 4601 D' - 25306 = 0$

Try D' = 3' ; -2780

Try D' = 3.5' ; +8112

Try D' = 3.1' ; -767

Try D' = 3.2' , +964

Try D' = 3.14 ; +62 OK

∴ D' = 3.14' Provide a 20%-40% length increase for adequate safety factor.

∴ Embedment = 3.14 × 1.3 = 4.1 Say 4.0' embedment

Therefore, pile tip elevation = 5520'

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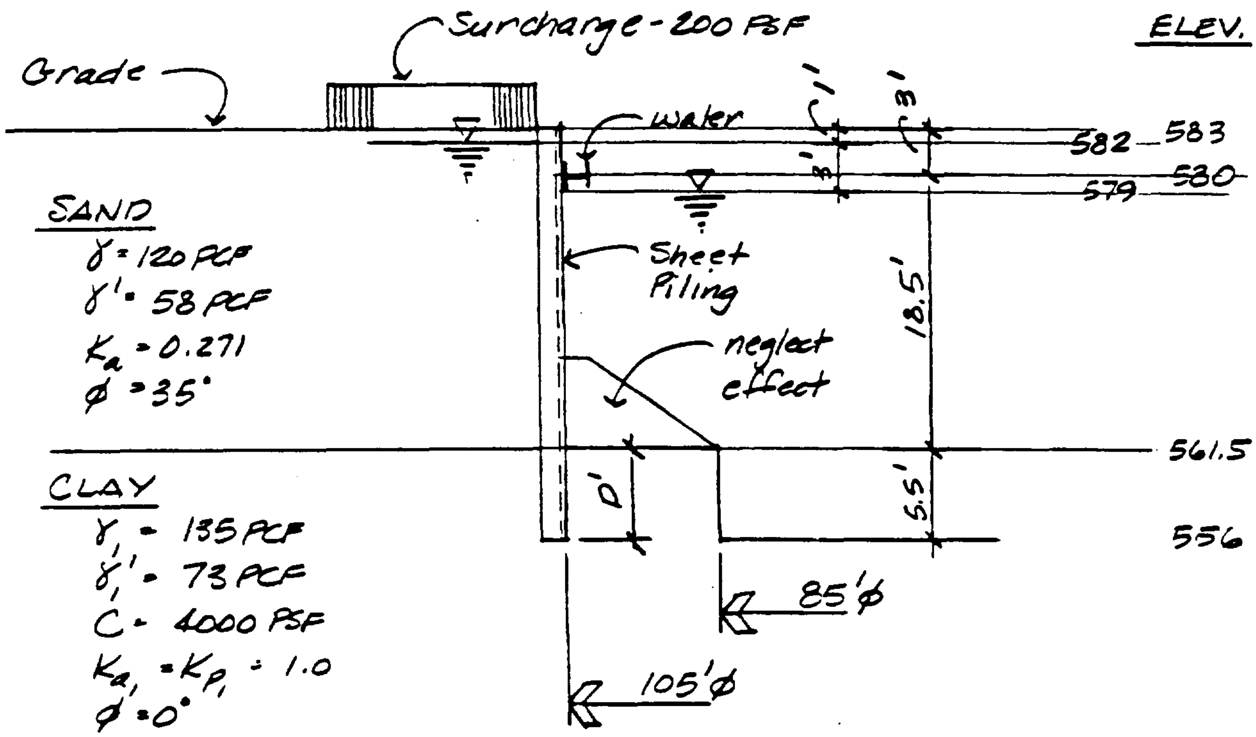
At Waukegan Marina, immediately south of the OMC site, driving heavy walled oil field pipe pile into the hard clay proved extremely difficult; pile tip elevation required at Waukegan was elevation 551.0. Therefore, it is our opinion that driving the steel sheet pile into the hardpan the required distance is not feasible. Therefore, provide a 105' diameter Cofferdam which allows for a 10 ft. buffer zone and berm at the interior of the cofferdam.

DRAFT



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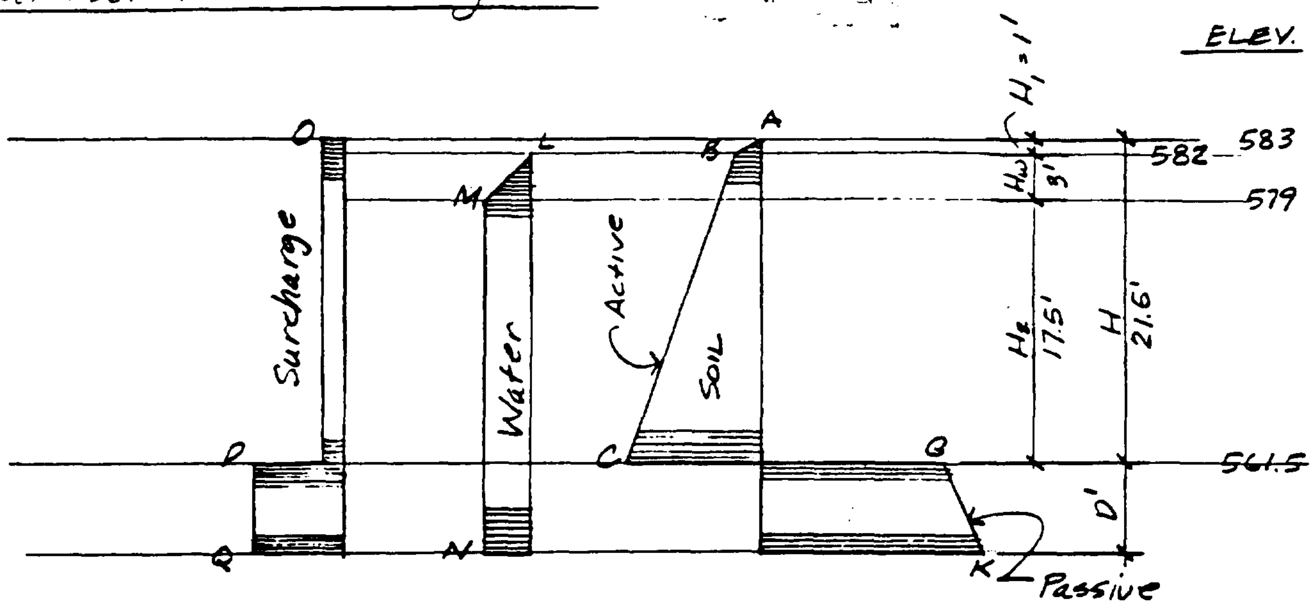
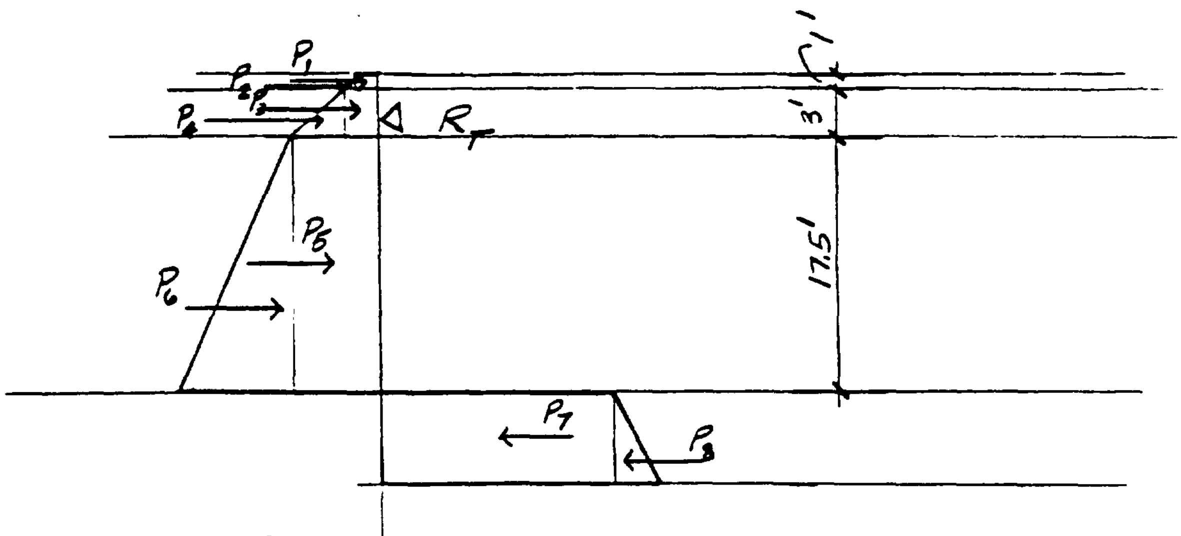
BY RAJ DATE 12-21-84 SUBJECT ACTION I - Cofferdam Design OMC/Waukegan Harbor SHEET NO. 10 OF 58
CHKD. BY KAN DATE 3/4/85 JOB NO. 11837

Lateral Pressure Diagram



Refer to pages 4 & 5 for calculation of lateral pressure at various locations.

Final Lateral Pressure Diagram



Refer to page 6 for cumulative pressures
Refer to page 7 for calculation of equivalent beam reactions for portion above point of contraflexure

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BY RAJ DATE 12-21-84 SUBJECT Action L Cofferdam Design OMC/Waukegan Harbor SHEET NO. 11 OF 53
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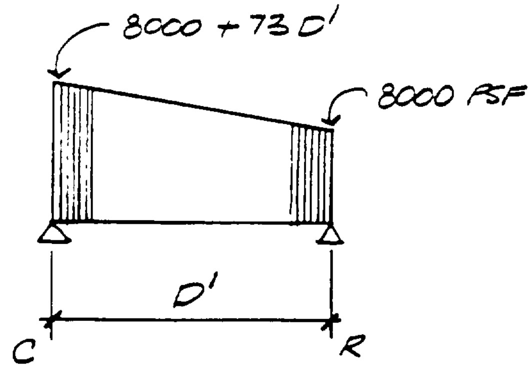

Calculate D' ; $\Sigma M @ C = 0$

$$8000\,D' \times D' \times 1/2 + 73\,D' \times D' \times 1/2 \times D' \times 1/3 - R \times D' = 0$$

$$4000(D')^2 + 12.17(D')^3 - R \times D' = 0$$

$$12.17(D')^2 + 4000\,D' - R = 0$$

$$(D')^2 + 328.68\,D' - \frac{4601}{12.17} = 0 \quad (378.06)$$

$$\therefore D' = \frac{-328.68 + \sqrt{328.68^2 + 4 \times 378.06}}{2} = 1.146'$$

Allowing for safety factor provide a 2' embedment

Check embedment requirement utilizing the "Free Earth Support Method"*

Solve for D' by summing moments about Waler location.

Refer to Loads on page No. 10

* USS Steel Sheet Pile Design Manual

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BY RAV DATE 12-21-84 SUBJECT Action 1- Cofferdam Design OMC/Waukegan Harbor SHEET NO. 12 OF 58
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MARK	FORCE	ARM	MOMENT
P_1	-54 #/FT	2.5'	-135 1-#/FT
P_2	-17 #/FT	2.33'	-40 1-#/FT
P_3	-261 #/FT	0.5'	-130 1-#/FT
P_4	353 #/FT	0'	0
P_5	5635 #/FT	9.75'	54941 1-#/FT
P_6	2406 #/FT	12.67	30484 1-#/FT
P_7	$-8000D'$	$18.5+D/2$	$-148000D'-4000(D')^2$
P_8	$-36.5(D')^2$	$18.5+2D'/3$	$-675(D')^2-24.33(D')^3$

DRAFT

$$\Sigma M = 85120 - 148000(D') - 4675(D')^2 - 24.33(D')^3$$

Try $D' = 0.5$; 9948

Try $D' = 0.55$; 2302

Try $D' = 0.56$; 770

Try $D' = 0.57$; -763

Therefore $D' \sim 0.565$; Req'd embedment is ~1'

It appears that the equivalent beam method provides a more conservative embedment. Therefore, provide a 2' embedment. Pile tip elev. = 559.5'

Determine point of Maximum moment

Maximum moment occurs @ point of zero shear. Assume this distance to be "x" Feet below point "C" (Water elev. @ cofferdam interior)

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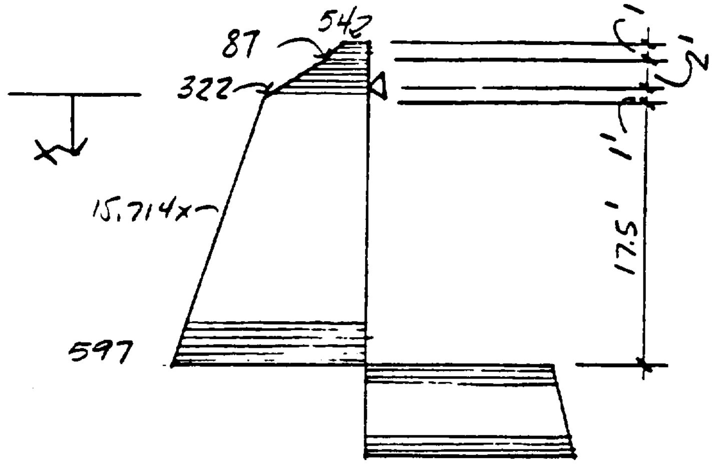


RE Waler = 4125# ; pg. 7

$\therefore\ 4125 - P_1 - P_2 - P_3 - P_4 - (322 + 322 + 15.714x)\frac{x}{2} = 0$

$4125 - 54 - 17 - 261 - 353 - 322x - 7.857x^2 = 0$

$x^2 + 40.983x - 437.8 = 0$

$\therefore\ x = \dfrac{-40.983 + \sqrt{40.983^2 + 4 \times 437.8}}{2} = 8.795'$

Sum moments about point of zero shear to determine maximum moment

Mark	FORCE (#/FT)	ARM (FT)	MOMENT (1-#/FT)
P_1	54	12.295'	664
P_2	17	12.13'	206
P_3	261	10.295'	2687
P_4	353	9.795	3458
	353 × 8.795	8.795/2	13653
	$15.714 \times 8.795^2/2$	8.795/3	1782
R_T	-4125	9.795	-40404
TOTAL			-17954 1-#/FT

DRAFT

S_{reqd} = Section modulus required = $\frac{M}{F_b}$

A328 material; therefore, F_b = 25^{KSI}

$\therefore S_{reqd.} = \frac{17{,}954^{1-k} \times 12}{25} = 8.62 \ in^3/FT. WALL$

Based on strength per weight provide PZ-27; Section modulus per foot of wall = 30.2 in^3. If this shape can not provide the circular configuration provide PDA 27; $S = 10.7$.

Wale Design

Determine axial load in wale resulting from circular configuration.

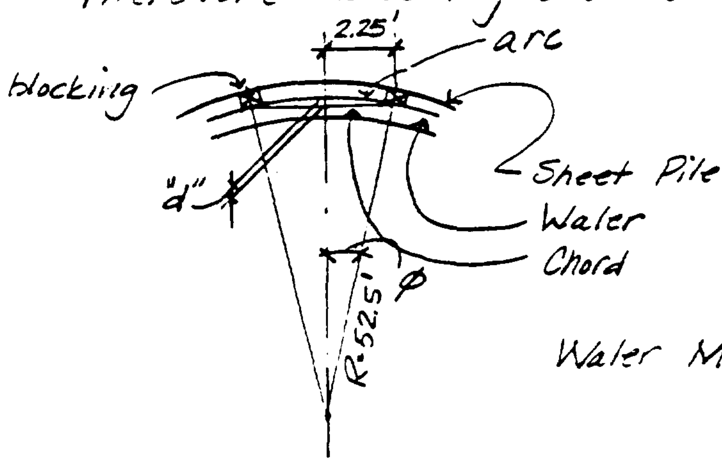
$P = R_T \times D \times 1/2 = 4125 \times 105 \times 1/2 = 216563^{\#}$

Provide sufficient blocking to fully brace flanges to prevent lateral buckling.

Assume blocking points, between waler and sheet pile, occur at every third sheet pile.

Therefore blocking distance = 3x driving width per sheet

$= 3 \times 1.5 = 4.5'$



d = rise between blocking points - chord and arc

Waler Moment = 0.86 Td

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$\sin\phi = \frac{2.25}{52.5}$; $\phi = 2.4563°$

$d = R - R \times \cos\phi = (52.5 - 52.5 \times \cos 2.4563°) \times 12 = 0.579''$

$\therefore$ Moment $= 0.86\,Td = 0.86 \times 216563 \times .579$
$= 107805^{\text{in-lb}}$

Try W10x49

$r_x = 4.35''$
$r_y = 2.54''$
$l_y = 9'$
$A = 14.4^{\square''}$
$S_x = 54.6\,in^3$
$r_T = 2.74''$
$d/A_f = 1.78''$

$\frac{Kl}{r_x} = \frac{4.5 \times 12}{4.35} = 12.4 \therefore F_a = 21.03^{\text{KSI}}$

$\frac{Kl}{r_y} = \frac{9 \times 12}{2.54} = 42.5 \quad \therefore F_a = 18.99^{\text{KSI}}$

$f_a = \frac{P}{A} = \frac{216563^{\#}}{14.4 \times 10^3} = 15.04^{\text{KSI}}$

$\therefore f_a/F_a = \frac{15.04}{18.99} = 0.792 > 0.15$

$F_b = \frac{170 \times 10^3 C_b}{(l/r_T)^2} = \frac{170 \times 10^3 \times 1.0}{(9 \times 12/2.74)^2} = 109.4 >> .6F_y$

$\therefore F_b = .6F_y = 22^{\text{KSI}}$

$\therefore \frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}} \le 1.0$ AISC 1.6-1a

$F'_{ex} = \frac{12\pi^2 E}{23(Kl/r)^2} = \frac{12\pi^2 \times 29 \times 10^3}{23(12.4)^2} = 971.2^{\text{KSI}}$

$f_{bx} = \frac{M_x}{S_x} = \frac{107805}{10^3 \times 54.6} = 1.97^{\text{KSI}}$

$$\therefore\ 0.792 + \frac{1.0 \times 1.97}{\left(1 - \frac{15.04}{971.2}\right)22} = 0.883 < 1.0 \quad \therefore \text{OK}$$

Investigate the W10x49 with a 10.5' unbraced length

$$\frac{K\ell_x}{r_x} = \frac{4.5 \times 12}{4.35} = 12.4 \ \therefore\ F_a = 21.03^{ksi}$$

$$\frac{K\ell}{r_y} = \frac{10.5 \times 12}{2.54} = 49.6 \ \therefore\ F_a = 18.38^{ksi}$$

$$f_a = \frac{P}{A} = \frac{216.563}{14.4} = 15.04^{ksi}, \quad f_a/F_a = \frac{15.04}{18.38} = 0.818 > .15$$

$$F_b = \frac{170 \times 10^3 C_b}{(\ell/r_T)^2} = \frac{170 \times 10^3 \times 1.0}{\left(10.5 \times 12/2.74\right)^2} = 80.4 > .6F_y$$

$$\therefore F_b = 0.6F_y = 0.6 \times 36 = 22^{ksi}$$

$$F_{e_x}' = \frac{12\pi^2 E}{23(K\ell_x/r_x)^2} = \frac{12\pi^2 \times 29 \times 10^3}{23 \times (12.4)^2} = 971.2^{ksi}$$

$$f_{b_x} = M_x/S_x = \frac{107805}{54.6 \times 10^3} = 1.97^{ksi}$$

$$\therefore \frac{f_a}{F_a} + \frac{C_{m_x} f_{b_x}}{\left(1 - f_a/F_{e_x}'\right) F_{b_x}} \le 1.0$$

$$0.818 + \frac{1.0 \times 1.97}{\left(1 - \frac{15.04}{971.2}\right)22} = 0.91 < 1.0$$

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Investigate the W10x49 Waler with a 13.5' unbraced length

$\frac{Kl_x}{r_x} = \frac{4.5 \times 12}{4.35} = 12.4 \quad \therefore F_a = 21.03^{ksi}$

DRAFT

$\frac{Kl_y}{r_y} = \frac{13.5 \times 12}{2.54} = 63.8 \quad \therefore F_a = 17.06^{ksi}$

$f_a = \frac{P}{A} = \frac{216.563}{14.4} = 15.04^{ksi}; \; f_a/F_a = \frac{15.04}{17.06} = 0.882 > 0.15$

Refer to page 16 for F_b, F_{ex}' and f_{bx}

$$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F_{ex}'}\right) F_{bx}} \leq 1.0$$

$$0.882 + \frac{1.0 \times 1.97}{\left(1 - \frac{15.04}{971.2}\right) 22} = 0.973 < 1.0 \quad \text{within } 5\% \therefore \underline{OK}$$

NOTE:
In reviewing the circular cofferdam system in its entirety, rather then individual components, it is apparent that the waler does not act as a true compression ring because it is not uniformly loaded around the perimeter. The force exerted at the waler elevation is substantially greater at that portion retaining earth then at the remaining. Therefore, this unbalanced force would need to be resisted by cantilevered sheet pile section for those pieces transverse to the load and diaphragm action for those pieces parallel to the direction of the load. By inspection neither of these possibilities appears sufficient to resist racking. Therefore, tieback earth retaining

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BY KAV DATE 12-27-84 SUBJECT Action 1 - Cofferdam Design SHEET NO. 18 OF 58
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portion of cofferdam structure

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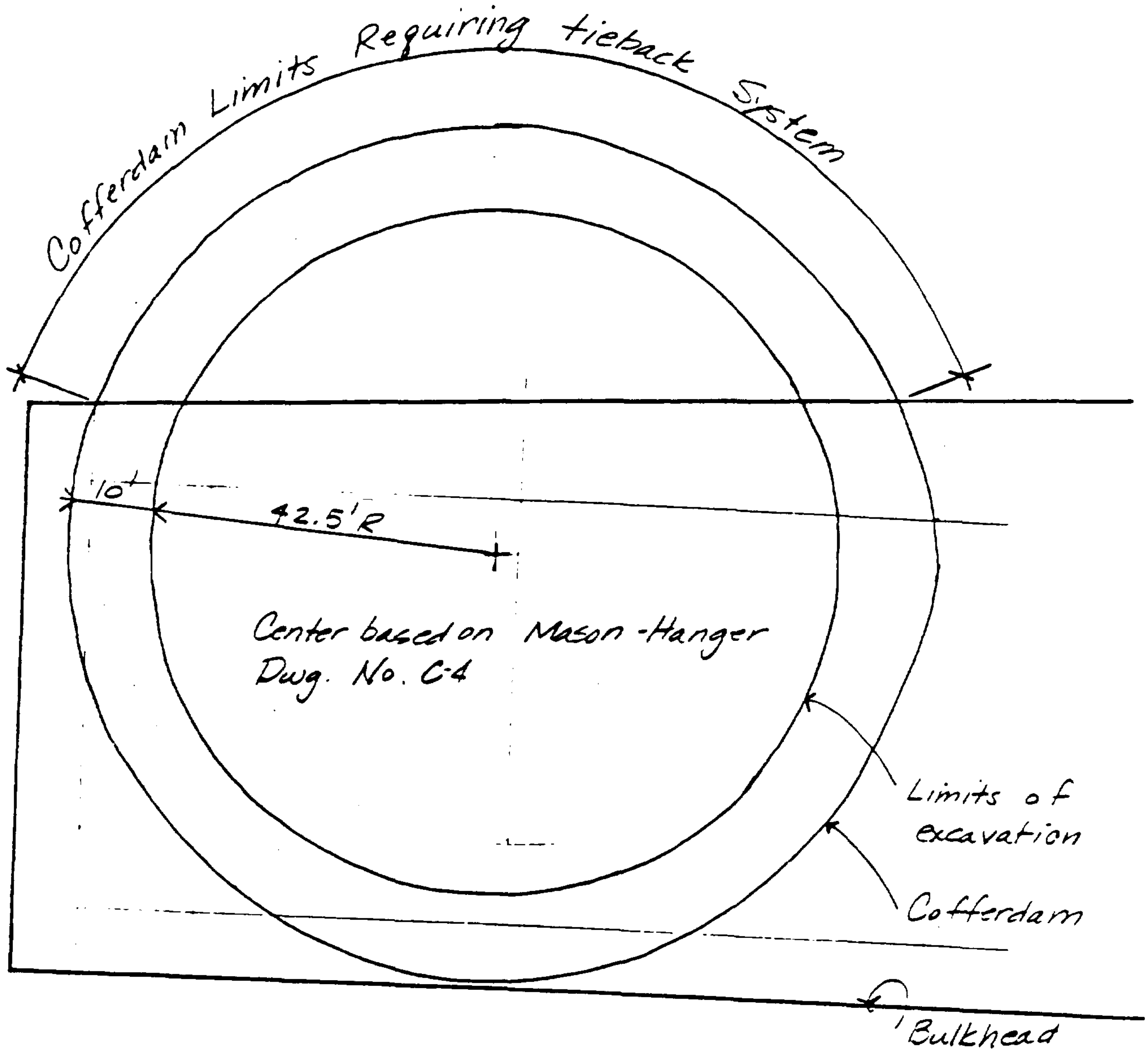
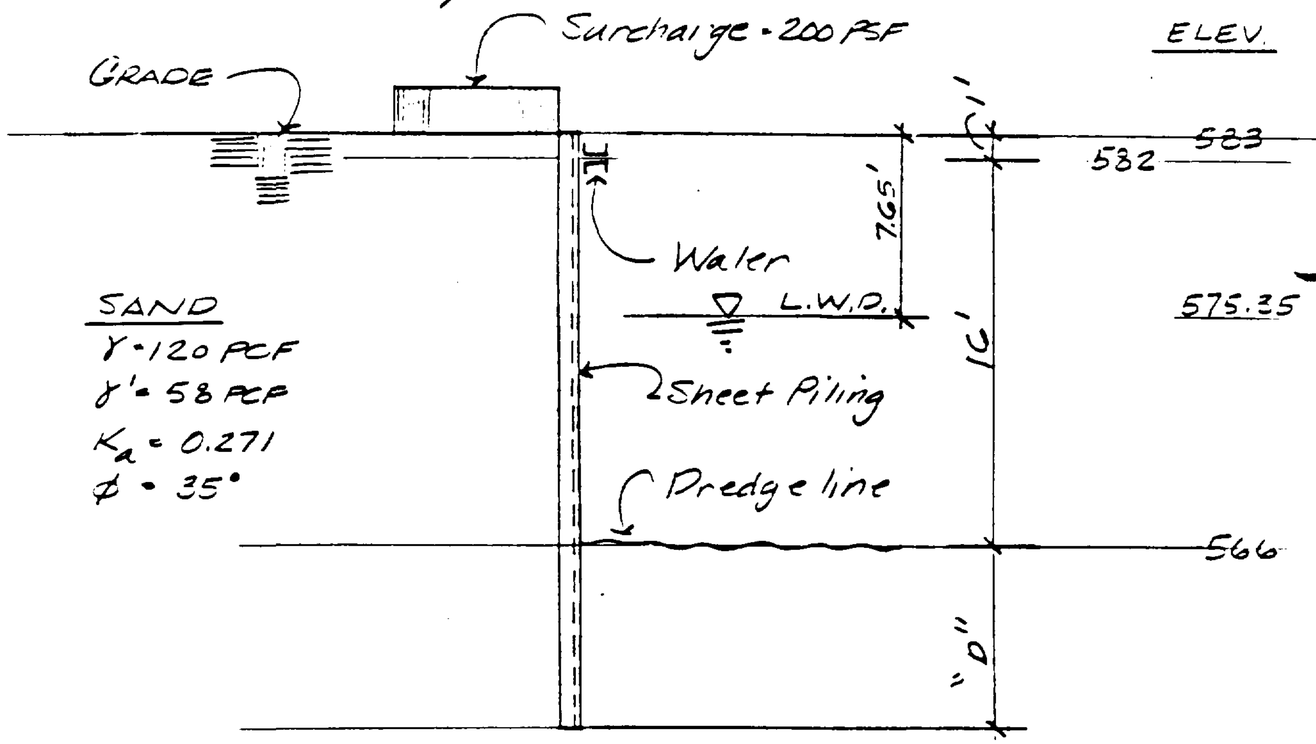
Tieback System Location

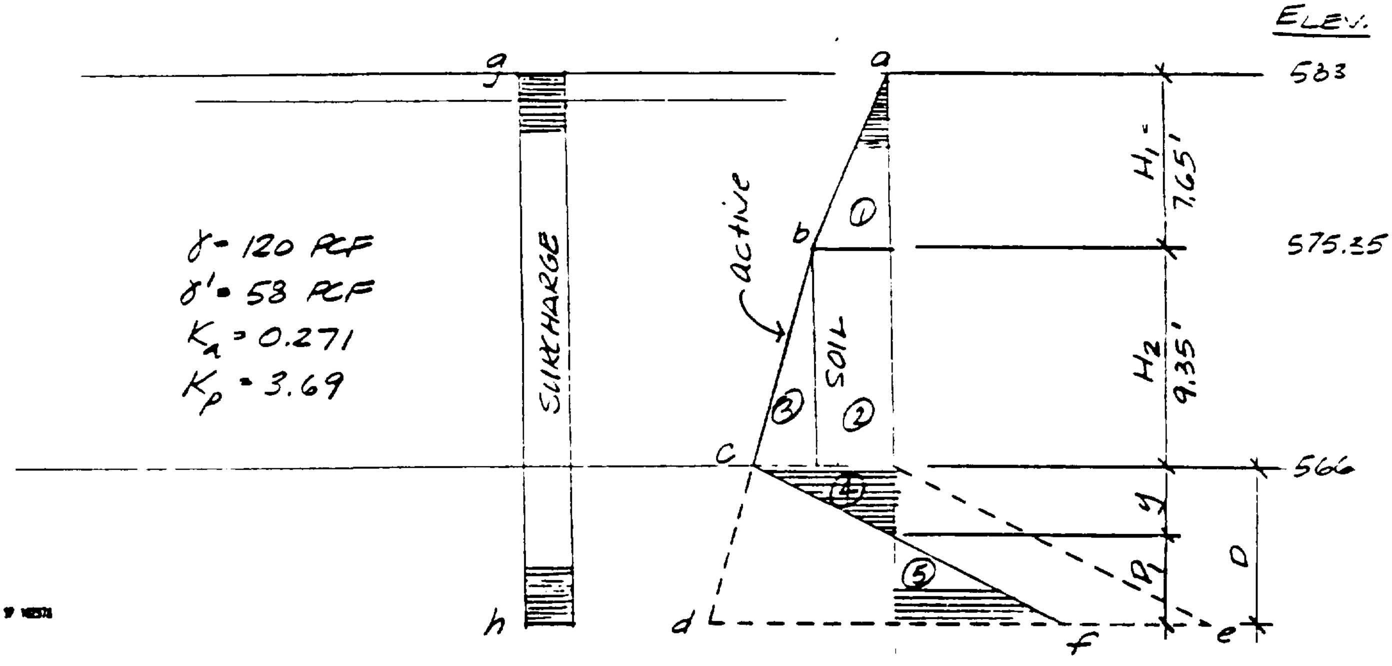


1. Design Bulkhead Wall Replacement

Dredgeline elevation appears to be approximately 566 at the worse location. Assume that sheetpile does not extend into hard clay.



Lateral Pressure Diagram



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BY RAJ DATE 12-27-84 SUBJECT Action 1 - Cofferdam Design OMC/Waukegan Harbor SHEET NO. 20 OF 58
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Calculate Lateral Pressures @ Locations of Change -

$P_b = \gamma H_1 K_a = 120 \times 7.65 \times .271 = 249$ PSF

DRAFT

$P_c = P_b + \gamma' H_2 K_a = 249 + 58 \times 9.35 \times .271 = 396$ PSF

$P_d = P_c + \gamma' D K_a = 396 + 58 \times D \times .271 = 396 + 15.7D$

$P_e = \gamma' D K_p = 58 \times D \times 3.69 = 214D$

$P_g = P_h = \text{Surcharge} \times K_a = 200 \times .271 = 54$ PSF

$P_f = P_e - P_d - P_h = 214D - (396 + 15.7D) - 54$

$= 198.3D - 450 = 198.3(D_1 + y) - 450$

Determine "y"

$$y = \frac{P_c + P_h}{\gamma'(K_p - K_a)} = \frac{396 + 54}{(58)(3.69 - .271)} = 2.27'$$

Resultants of Pressures

$P_1 = P_b \times H_1 \times 1/2 = 249 \times 7.65 \times 1/2 = 953$ #/FT

$P_{1a} = P_g \times H_1 = 54 \times 7.65 = 413$ #/FT

$P_2 = (P_b + P_g) \times H_2 = (249 + 54) \times 9.35 = 2833$ #/FT

$P_3 = (P_c - P_b) \times H_2 \times 1/2 = (396 - 249) \times 9.35 \times 1/2 = 687$ #/FT

$P_4 = (P_c + P_h) \times y \times 1/2 = (396 + 54) \times 2.27 \times 1/2 = 511$ #/FT

$P_5 = P_f \times D_1 \times 1/2 = (198.3(D_1 + 2.27) - 450) \times D_1 \times 1/2$
$= 99.2 D_1^2$

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SHEET NO. 21 OF 58
JOB NO. 11837

Sum Moments about tieback ; $\Sigma M_{@tieback} = 0$

Mark	Force	Arm	Moment
P_1	953	$7.65 \times 2/3 - 1$	3907 1-#/FT
P_{1a}	413	$7.65/2 - 1$	1167 1-#/FT
P_2	2833	$9.35/2 + 6.65$	32084 1-#/FT
P_3	687	$9.35 \times 2/3 + 6.65$	8851 1-#/FT
P_4	511	$2.27/3 + 16$	8563 1-#/FT
P_5	$-99.2 D_1^2$	$D_1 \times 2/3 + 18.27$	$-66.1 D_1^3 - 1812.4 D_1^2$

$\Sigma M_{@tieback} = 54572 - 66.1 D_1^3 - 1812.4 D_1^2 = 0$

Try $D = 5$; $54572 - 66.1 \times 5^3 - 1812.4 \times 5^2 = 999.5$

Try $D = 5.1$; $54572 - 66.1 \times 5.1^3 - 1812.4 \times 5.1^2 = -1336.8$

Try $D = 5.04$; $54572 - 66.1 \times 5.04^3 - 1812.4 \times 5.04^2 = 71.8$ OK

Total Penetration $= y + D_1 = 2.27 + 5.04 = 7.31'$

Because the sand layer thickness is only about 5' it is apparent that the sheet pile wall will need to penetrate the hard clay some nominal amount to achieve adequate lateral resistance @ toe.

The length of the existing sheet piles is apparently in the range of 18-20 ft. This allows for toe penetration in the range of 2-5 ft. Therefore, analyze wall utilizing the coulomb method for lateral pressures, taking advantage of the friction between wall and soil.

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DRAFT

$$K_a = \frac{\cos^2\phi}{\cos\delta\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\cos\delta\cos\beta}}\right]^2}$$

ϕ = angle of internal friction of soil = 35°
δ = angle of wall friction = 15°
β = angle of backfill = 0°

$$\therefore K_a = \frac{\cos^2 35}{\cos 15\left[1+\sqrt{\frac{\sin(35+15)\sin 35}{\cos 15\times\cos 0}}\right]^2} = \frac{.671}{.966\left[1+\sqrt{.4549}\right]^2}$$

$= 0.248$

$$K_p = \frac{\cos^2\phi}{\cos\delta\left[1-\sqrt{\frac{\sin(\phi+\delta)\sin(\phi+\beta)}{\cos\delta\cos\beta}}\right]^2}$$

$$= \frac{\cos^2 35}{\cos 15\left[1-\sqrt{\frac{\sin(35+15)\sin(35+0)}{\cos 15\cos 0}}\right]^2} = \frac{.671}{.966\left[1-\sqrt{.4549}\right]^2}$$

$= 6.55$

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BY RAV DATE 1-3-85 SUBJECT ACTION 1: Cofferdam Design OMC/Waukegan Harbor SHEET NO. 23 OF 53
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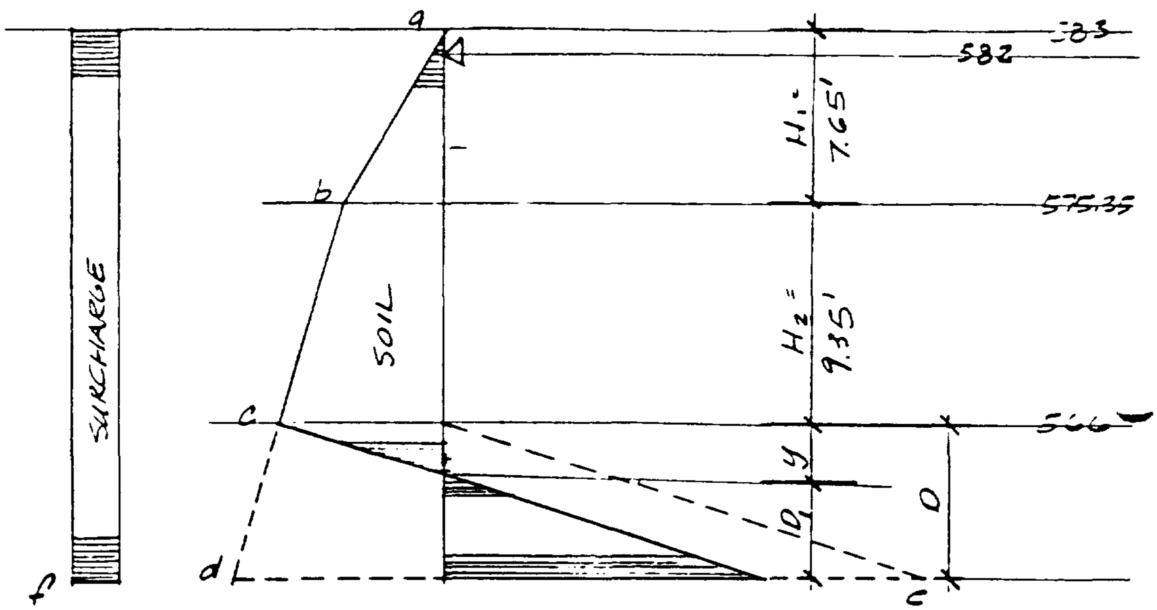
Lateral Pressure Diagram

DRAFT

$\gamma = 120$ PCF
$\gamma' = 58$ PCF
$K_a = 0.248$
$K_p = 6.55$



$P_b = \gamma H_1 K_a = 120 \times 7.65 \times .248 = 228$ #/FT/FT

$P_c = P_b + \gamma' H_2 K_a = 228 + 58 \times 9.35 \times .248 = 362$ #/FT/FT

$P_d = P_c + \gamma' D K_a = 362 + 58D \times .248 = 362 + 14.4\,D$

$P_e = \gamma' D K_p = 58 \times D \times 6.55 = 380\,D$

$P_f =$ Surcharge $\times K_a = 200 \times .248 = 50$ #/FT/FT

Develop a composite lateral Pressure diagram

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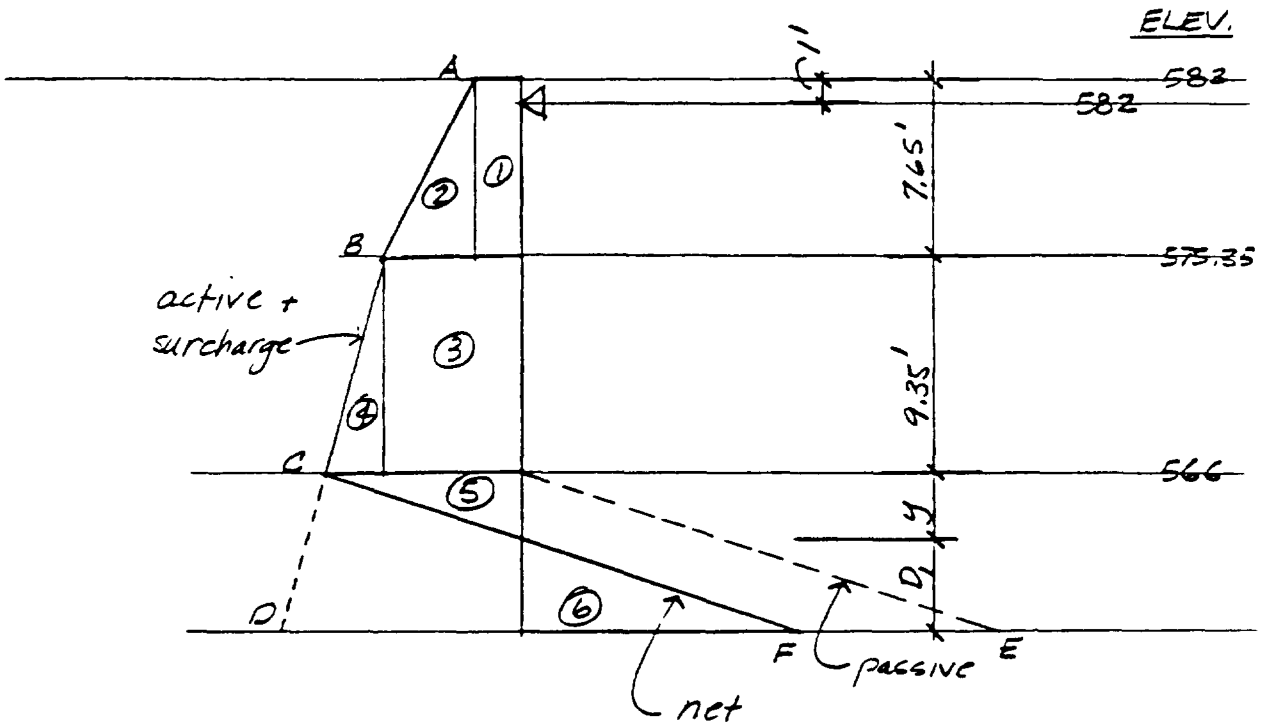
Composite Lateral Pressure Diagram

DRAFT



Compute Lateral Pressures @ Locations of Change

$P_A = P_f = 50$ #/FT/FT

$P_B = P_b + P_f = 228 + 50 = 278$ #/FT/FT

$P_C = P_c + P_f = 362 + 50 = 412$ #/FT/FT

$P_D = P_d + P_f = 362 + 14.4D + 50 = 412 + 14.4D$

$P_E = P_e = 380D$

$P_F = P_E - P_D = 380D - 412 - 14.4D = 365.6D - 412$

Determine "y"

$$y = \frac{P_c}{\gamma'(K_p - K_a)} = \frac{412}{58(6.55 - .248)} = 1.127'$$

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Resultants of Pressures

DRAFT

$P_1 = P_A \times H_1 = 50 \times 7.65 = 383$ #/FT

$P_2 = (P_B - P_A) \times H_1 \times 1/2 = (278-50) \times 7.65 \times 1/2 = 872$ #/FT

$P_3 = P_B \times H_2 = 278 \times 9.35 = 2600$ #/FT

$P_4 = (P_C - P_B) \times H_2 \times 1/2 = (412-278) \times 9.35 \times 1/2 = 626$ #/FT

$P_5 = P_C \times y \times 1/2 = 412 \times 1.127 \times 1/2 = 232$ #/FT

$P_6 = (365.6D - 412) \times D_1 \times 1/2 = (365.6(D_1+y) - 412) \times D_1 \times 1/2 =$

$(365.6(D_1+1.127) - 412) \times D_1 \times 1/2 = 365.6D_1 \times D_1 \times 1/2 = 182.8\,D_1^2$

Sum Moments about tieback; $\Sigma M_{@TIEBACK} = 0$

Mark	Force	Arm	Moment
P_1	383	$7.65 \times 1/2 - 1 = 2.825$	1082 1-#/FT
P_2	872	$7.65 \times 2/3 - 1 = 4.1$	3575 1-#/FT
P_3	2600	$9.35 \times 1/2 + 6.65 = 11.325$	29445 1-#/FT
P_4	626	$9.35 \times 2/3 + 6.65 = 12.883$	8065 1-#/FT
P_5	232	$1.127 \times 1/3 + 16 = 16.376$	3799 1-#/FT
P_6	$-182.8\,D_1^2$	$D_1 \times 2/3 + 17.127$	$-121.9\,D_1^3 - 3131\,D_1^2$

$\therefore \Sigma M_{@TIEBACK} = 45966 - 121.9D_1^3 - 3131\,D_1^2 = 0$

Try $D_1 = 4'$; $45966 - 121.9 \times 4^3 - 3131 \times 4^2 = -11932$

Try $D_1 = 3.5'$; $45966 - 121.9 \times 3.5^3 - 3131 \times 3.5^2 = +2385$

Try $D_1 = 3.59'$ $45966 - 121.9 \times 3.59^3 - 3131 \times 3.59^2 = -27$ OK

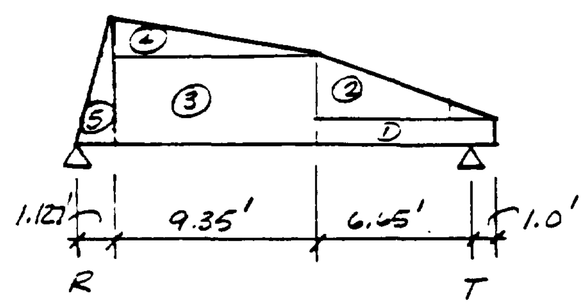
Total Penetration = D = y + D_1 = 1.127 + 3.59' = 4.717'

To provide a margin of safety, increase D by a factor of 20%-40%

Use D = 5.75' Therefore, it would appear that in most locations at the end of slip No.3 adequate toe penetration is achieved without penetration into the hard silt.

Check Toe Penetration With the Equivalent Beam Method

Assume point of contraflexure occurs @ point of zero pressure, a distance "y" below dredge line

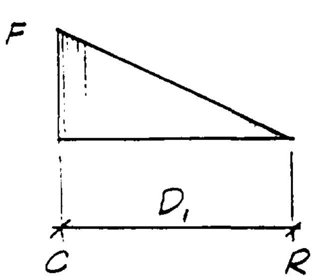


DRAFT

$\Sigma M @ T = 0$

$\therefore\ 383 \times 2.825 + 872 \times 4.1 + 2600 \times 11.325 + 626 \times 12.883 + 232 \times 16.376 - R \times 17.127 = 0$

$\therefore\ R = 2684$ #/FT



$\Sigma M @ C = 0$

$$\frac{\gamma'(K_p - K_a) D_1^2}{2} \times \frac{D_1}{3} - R D_1 = 0$$

$$\frac{58(6.55 - .248) D_1^2}{2} \times \frac{D_1}{3} - 2684 D_1 = 0$$

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$60.92 D_1^3 - 2684 D_1 = 0$

$60.92 D_1^2 - 2684 = 0$; $D_1^2 = \frac{2684}{60.92}$ $\therefore D_1 = 6.64'$

$\therefore D = 6.64 + 1.127 = 7.76'$ Compares to $4.717'$

Therefore, it appears that the sheet pile bulkhead wall may have been driven deep enough to assure stability; however, not deep enough to prevent lateral deflection and rotation at the toe.

Determine force @ tieback elevation

$\Sigma F_H = 0$; Active - passive - T = 0

$\therefore T =$ Active - Passive $= P_1 + P_2 + P_3 + P_4 + P_5 - P_6$

$= 383 + 872 + 2600 + 626 + 232 - 182.8 \times 3.59^2$

$= 2357$ #/FT

Determine Maximum Moment - Occurs @ point of zero shear

Assume point of zero shear to occur at "x" feet below the water table.

$\Sigma F_H = 0$; $T = P_1 + P_2 + (P_B + P_B + \gamma' K_a "x") \times 1/2 \times "X"$

$2357 = 383 + 872 + (278 + 278 + 58 \times .248\,x) \times \frac{1}{2} x$

$1102 = (556 + 14.4x)\frac{x}{2}$; $1102 = 278x + 7.2\,x^2$

$\therefore x^2 + 38.6\,x - 153.06 = 0$

$$X = \frac{-38.6 + \sqrt{38.6^2 + 4 \times 153.06}}{2} = 3.625'$$

Sum moments about point of zero shear to determine maximum moment

$$383 \times (7.65 \times 1/2 + 3.625) + 872 \times (7.65 \times 1/3 + 3.625) + \frac{278 \times 3.625^2}{2}$$

$$+ 58 \times .248 \times 3.625 \times 1/2 \times 3.625 \times 1/3 - 2357 \times (6.65 + 3.625) = -14122 \text{ 1-\#/FT}$$

$$S_{req'd} = \frac{M}{F_b} = \frac{14122 \times 12}{10^3 \times 25} = 6.78 \text{ in}^3/\text{FT}$$

Section	Section modulus/Ft of wall	Wgt/□Ft of Wall
PDA 27	10.7 in^3	27 #/□'
PZ 27	30.2 in^3	27 #/□'

By inspection provide the PZ-27 pile because it provides greater section modulus for a comparable weight.

Waler Requirements

Assume tieback spacing = 10' ; ω = 2.357 K/FT pg 27

$$M_{max} = \frac{\omega l^2}{8} = \frac{2.357 \times 10^2}{8} = 29.5^{1-K} \quad ; \text{Try (2)-C10}\times 20$$

$$f_b = \frac{M}{S} = \frac{29.5 \times 12}{2 \times 15.8} = 11.2^{ksi} \quad ; \quad F_b = \frac{12 \times 10^3 C_b}{l\, d/A_f} \qquad \text{AISC 1.5-7}$$

$$\therefore F_b = 12 \times 10^3 / 10 \times 12 \times 8.36 = 11.96^{ksi} \qquad \therefore f_b/F_b = \frac{11.2}{11.96} = .94 \text{ OK}$$

Investigate bulkhead wall under a less severe loading condition for determining toe penetration required during construction. We can control the surcharge during this period, therefore, eliminate the surcharge. Also, assume the water level is at normal water elevation. Say elev 579.

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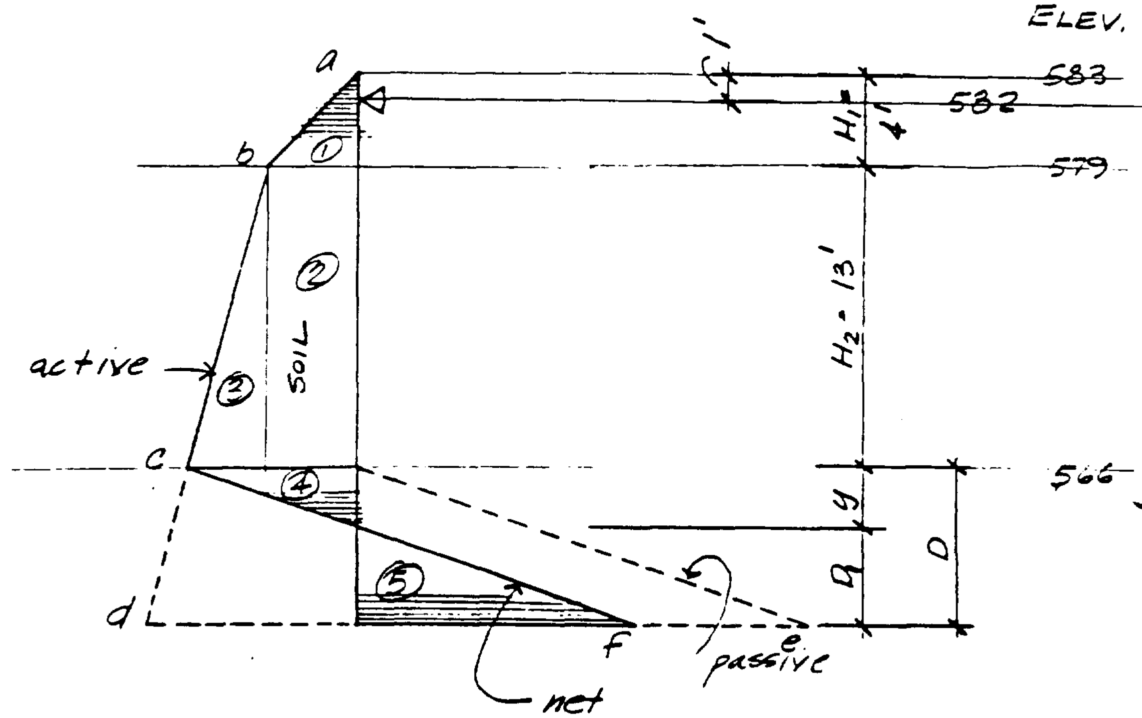
Lateral Pressure Diagram



$\gamma = 120$ PCF
$\gamma' = 58$ PCF
$K_a = 0.248$
$K_p = 6.55$

$P_b = \gamma H_1 K_a = 120 \times 4 \times .248 = 119$ #/FT/FT

$P_c = P_b + \gamma' H_2 K_a = 119 + 58 \times 13 \times .248 = 306$ #/FT/FT

$P_d = P_c + \gamma' D K_a = 306 + 58 \times D \times .248 = 306 + 14.4D$

$P_e = \gamma' D K_p = 58 \times D \times 6.55 = 380D$

$P_f = P_e - P_d = 380D - 306 - 14.4D = 365.6D - 306$

Determine "y"

$$y = \frac{P_c}{\gamma'(K_p - K_a)} = \frac{306}{58(6.55 - .248)} = 0.837'$$

9 M2374

Resultants of Pressure

$P_1 = P_b \times H_1 \times 1/2 = 119 \times 4 \times 1/2 = 238$ #/FT

$P_2 = P_b \times H_2 = 119 \times 13 = 1547$ #/FT

$P_3 = (P_c - P_b) \times H_2 \times 1/2 = (306 - 119) \times 13 \times 1/2 = 1216$ #/FT

$P_4 = P_c \times y \times 1/2 = 306 \times .837 \times 1/2 = 128$ #/FT

$P_5 = P_f \times D_1 \times 1/2 = (365.6D - 306) \times D_1 \times 1/2$

$= (365.6(D_1 + .837) - 306)\, D_1 \times 1/2$

$= (365.6\ D_1) \times D_1 \times 1/2 = 182.8\ D_1^2$

Sum Moments about tieback, $\Sigma M @ \text{TIEBACK} = 0$

Mark	Force	Arm	Moment
P_1	238	$4 \times 2/3 - 1 = 1.667$	397 1-#/FT
P_2	1547	$13 \times 1/2 + 3 = 9.5$	14697 1-#/FT
P_3	1216	$13 \times 2/3 + 3 = 11.667$	14187 1-#/FT
P_4	128	$.837 \times 1/3 + 16 = 16.279$	2084 1-#/FT
P_5	$-182.8\ D_1^2$	$D_1 \times 2/3 + 16.837$	$-121.9 D_1^3 - 3078 D_1^2$

Σ M Tieback $= 31365 - 121.9\ D_1^3 - 3078\ D_1^2 = 0$

Try $= 3$; $31365 - 121.9 \times 3^3 - 3078 \times 3^2 = 371.7$

Try 3.1 ; $31365 - 121.9 \times 3.1^3 - 3078 \times 3.1^2 = -1846.1$

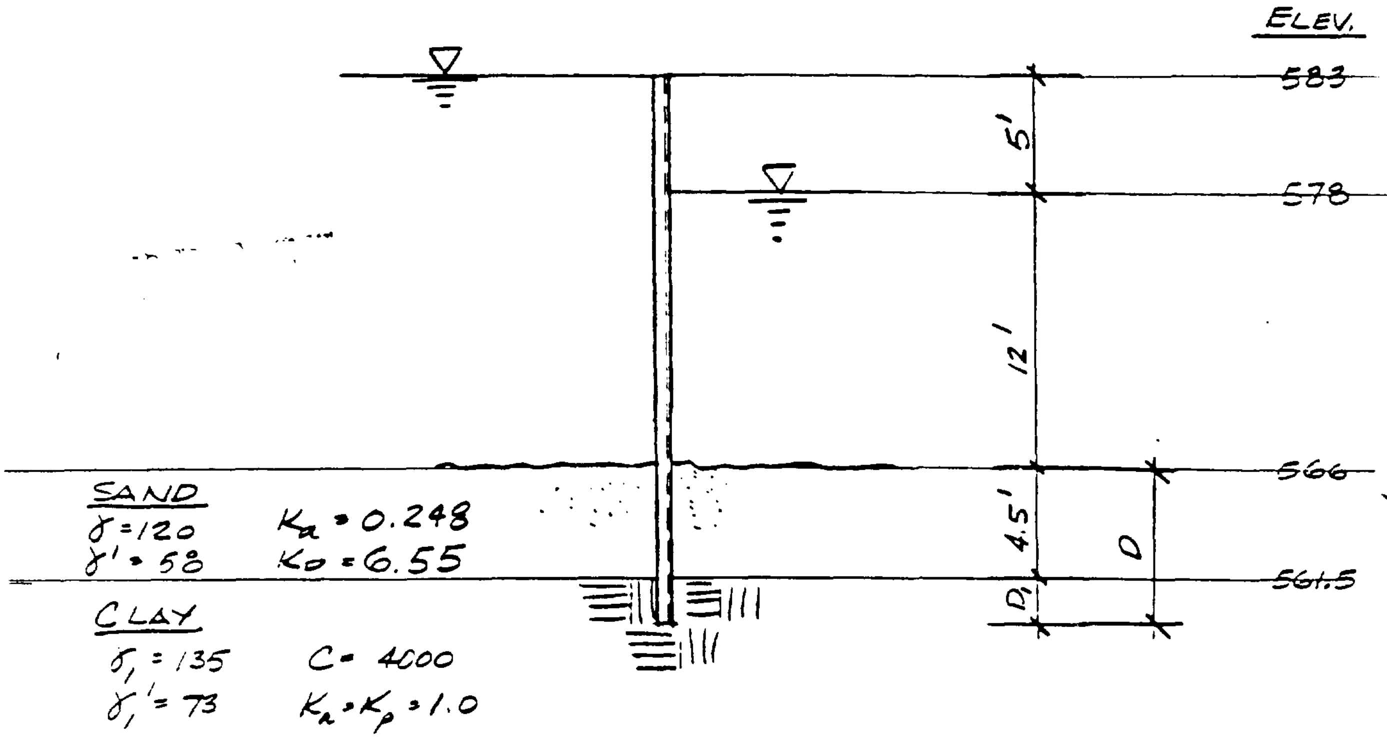
Try 3.017 ; $31365 - 121.9 \times 3.017^3 - 3078 \times 3.017^2 = +.6$ ∴ OK

Total Penetration $= D = y + D_1 = 0.837 + 3.017 = 3.854'$

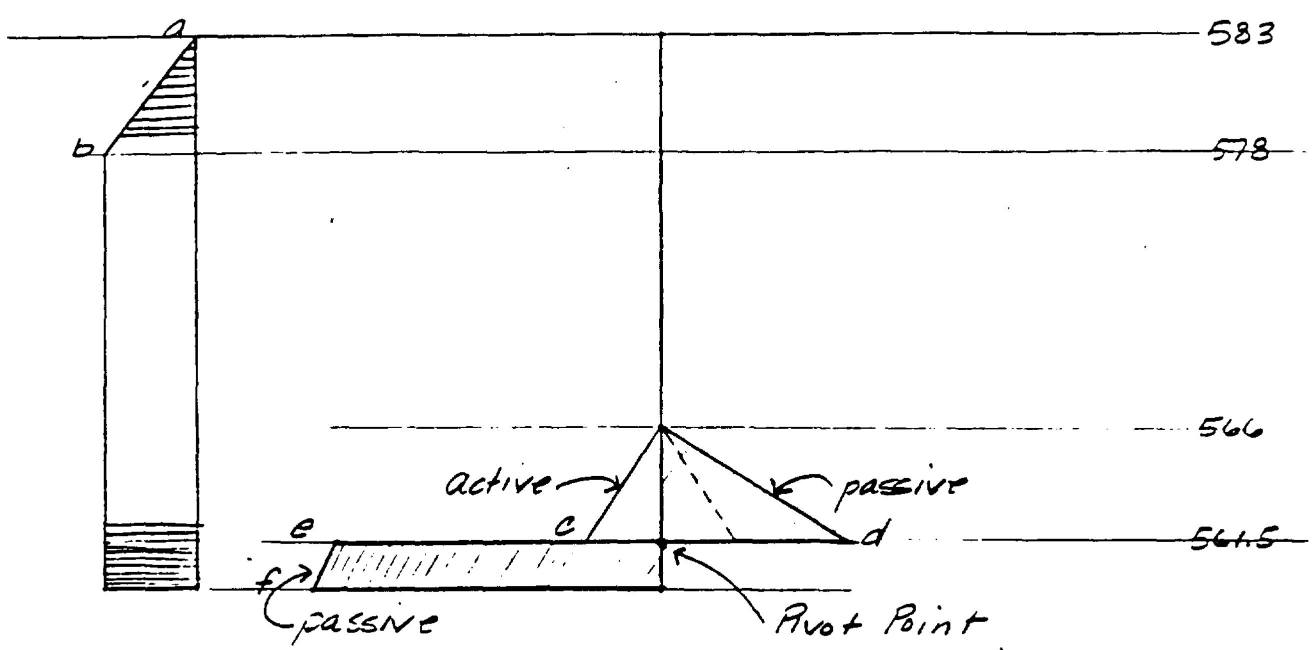
$\therefore$ With safety factor toe penetration of 4.75' is required. This is only 1' less than severe loading.

Design cantilevered single sheet pile wall across the width of slip No. 3 enclosing the area of high contamination.

Design for a differential water elevation of 5'

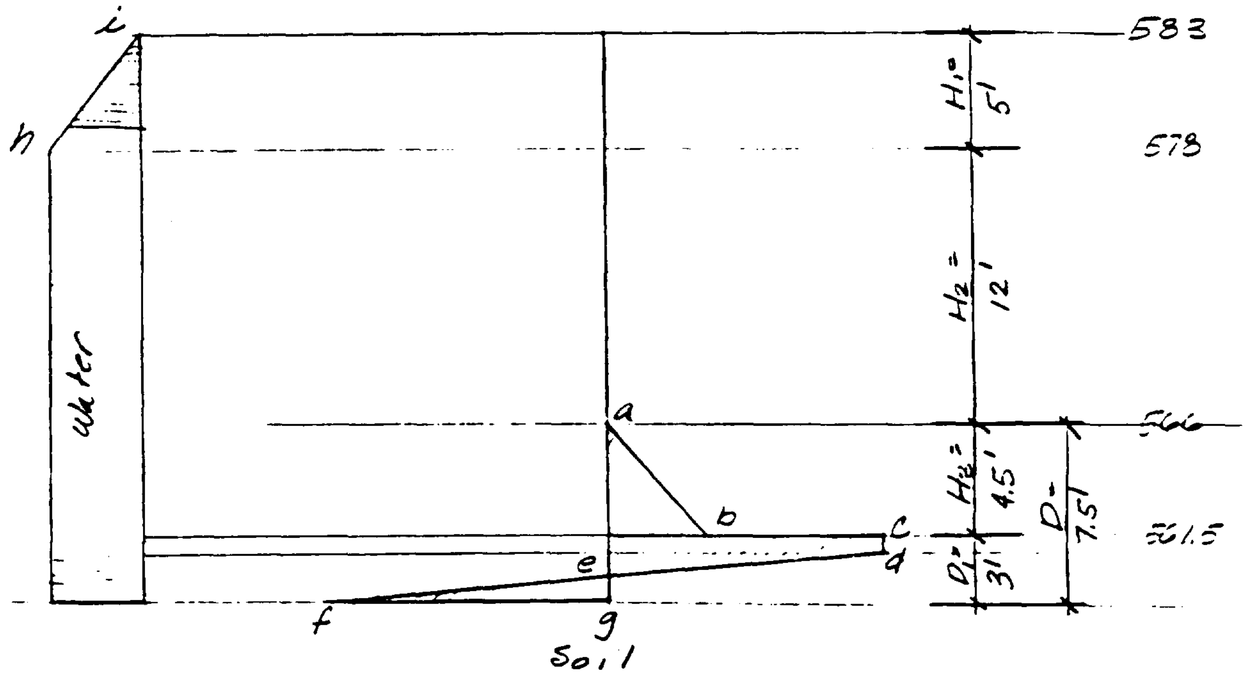


Lateral Pressure Diagram -



note: no active pressure within the clay material. See pg 4.

Assume that the point of rotation occurs in the clay layer and that the total penetration required is 7.5'



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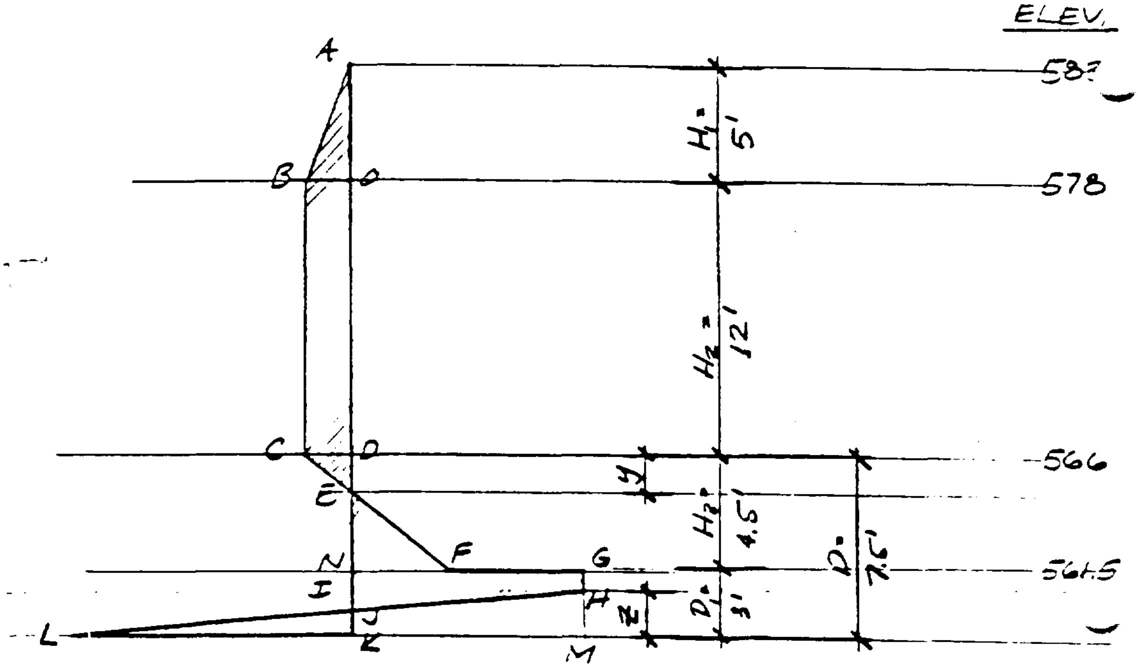
$P_b = \gamma'(K_p - K_a) H_3 = 58(6.55 - .248) 4.5 = 1645$ #/FT/FT

$P_c = P_D = 4C - \Sigma\gamma H = 4 \times 4000 - 0 = 16000$ #/FT/FT

$P_F = 4C + \Sigma\gamma H = 4 \times 4000 + 0 = 16000$ #/FT/FT

$P_h = \gamma_w H_1 = 62.5 \times 5 = 313$ #/FT/FT

FINAL LATERAL PRESSURE DIAGRAM



$P_B = P_h = 313$ #/FT/FT

$P_F = P_b - P_h = 1645 - 313 = 1332$ #/FT/FT

$P_G = P_H = P_c - P_h = 16000 - 313 = 15687$ #/FT/FT

$P_L = P_f + P_h = 16000 + 313 = 16313$ #/FT/FT

$$y = \frac{P_c}{\gamma'(K_p - K_a)} = \frac{313}{58(6.55 - .248)} = 0.856'$$

$\cdot 0$

$a(ABCE) - Area(EFN) - Area(NGMK) + Area(HLM) = 0$

$H_1 \times 1/2 + P_B H_2 + P_B \times y \times 1/2 - P_F (H_3 - y) 1/2 - P_G \times D_1 + (P_G + P_L) z \times 1/2 z$

$\frac{}{} 1/2 + 313 \times 12 + 313 \times .856 \times 1/2 - 1332 (4.5 - .856) 1/2 - 15687 \times 3$

$(6313 + 15687) z \times 1/2 = 0$;

$783 + 3756 + 134 - 2427 - 47061 + 16000 z = 0$

$\therefore 16000 z - 44815 = 0 \quad \therefore z = 2.80'$

Sum moments about the bottom ; $\Sigma M @ K = 0$

Area	Force	Arm	Moment
BO	783	21.2'	16600
BODC	3756	13.5'	50706
CDE	134	7.21'	966
EFN	-2427	4.21'	-10218
NGMK	-47061	1.5'	-70592
HLM	16000 z	z/3	5333.3 z^2

$\Sigma M @ K = -12538 + 5333.3 z^2 = 0$ $\therefore$ Greater embedment required

$\therefore z = 1.53' < 2.80'$

Try $D = 8'$ $\therefore D_1 = 3.5'$

$\Sigma F_H = 0$; $783 + 3756 + 134 - 2427 - 15687 \times 3.5 + 16000 z = 0$

$16000 z - 52659 = 0$; $z = 3.29'$

$\Sigma M @ K = 0$

Area	Force	Arm	Moment
ABO	783	21.7'	16991
BODC	3756	14.0'	52584
CDE	134	7.71'	1033
EFN	-2427	4.71'	-11431
NGMK	-54905	1.75'	-96084
HLM	16000Z	Z/3	$5333.3 Z^2$

$\Sigma M @ K = -36907 + 5333.3 Z^2 = 0 \quad \therefore Z = 2.63' < 3.29'$

$\therefore$ Greater embedment required.

Try $D = 8.5' \quad \therefore D_1 = 4.0'$

$\Sigma F_H = 0 \; ; \; 783 + 3756 + 134 - 2427 - 15687 \times 4 + 16000 Z = 0$

$16000 Z - 60502 = 0 \; ; \; Z = 3.781'$

$\Sigma M @ K = 0$

Area	Force	Arm	Moment
ABO	783	22.2'	17383
BODC	3756	14.5'	54462
CDE	134	8.21'	1100
EFN	-2427	5.21'	-12645
NGMK	-62748	2'	-125496
HLM	16000Z	Z/3	$5333.3 Z^2$

$\Sigma M @ K = -65196 + 5333.3 Z^2 = 0 \; ; \; Z = 3.50' < 3.781'$

Greater embedment reqd.

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Try $D = 9.0'$; $D_1 = 4.5'$

$\Sigma F_H = 0$; $783 + 3756 + 134 - 2427 - 15687 \times 4.5 + 16000 z = 0$

$16000 z - 68346 = 0$; $z = 4.272'$

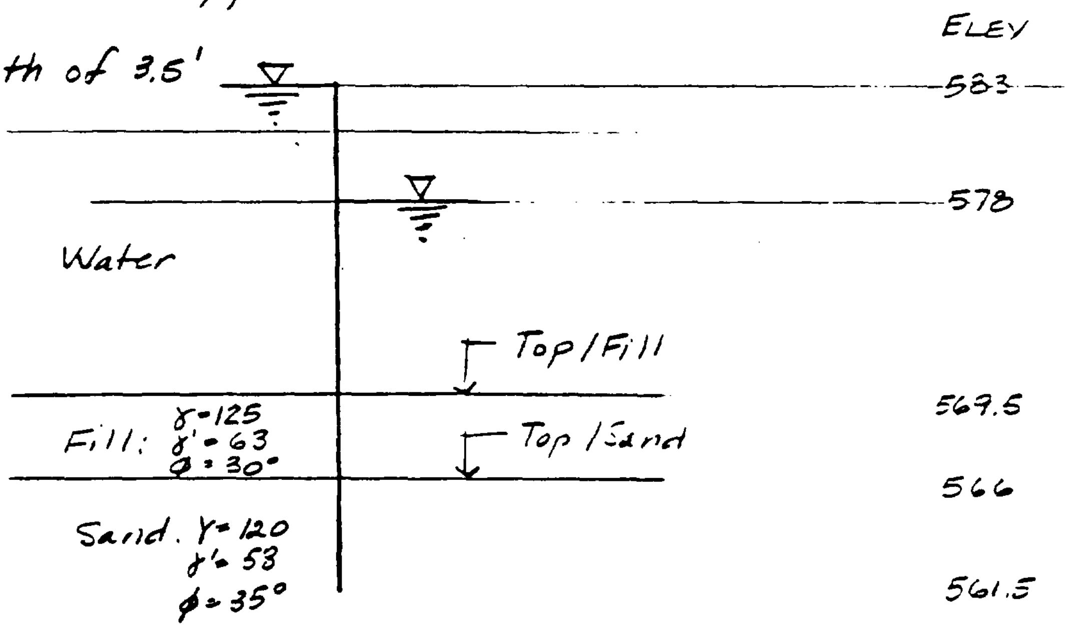
$\Sigma M @ K = 0$

Area	Force	Arm	Moment
ABO	783	22.7'	17774
BODC	3756	15.0'	56340
CDE	134	8.71'	1167
EFN	-2427	5.71'	-13858
NGMK	-70592	2.25'	-158832
HLM	16000 z	z/3	5333.3 z^2

$\Sigma M @ K = -97409 + 5333.3 z^2 = 0$, $z = 4.274 \approx 4.272 \therefore \underline{\underline{OK}}$

Because it may not be feasible to drive the sheet pile to this depth into the hard silt let us provide a berm on each side of the wall to offer the lateral support.

Try a fill depth of 3.5'



Determine active and passive pressure coefficients for fill zone.

$$K_a = \frac{\cos^2\phi}{\cos\delta\left(1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\cos\delta\cos\beta}}\right)^2}$$

DRAFT

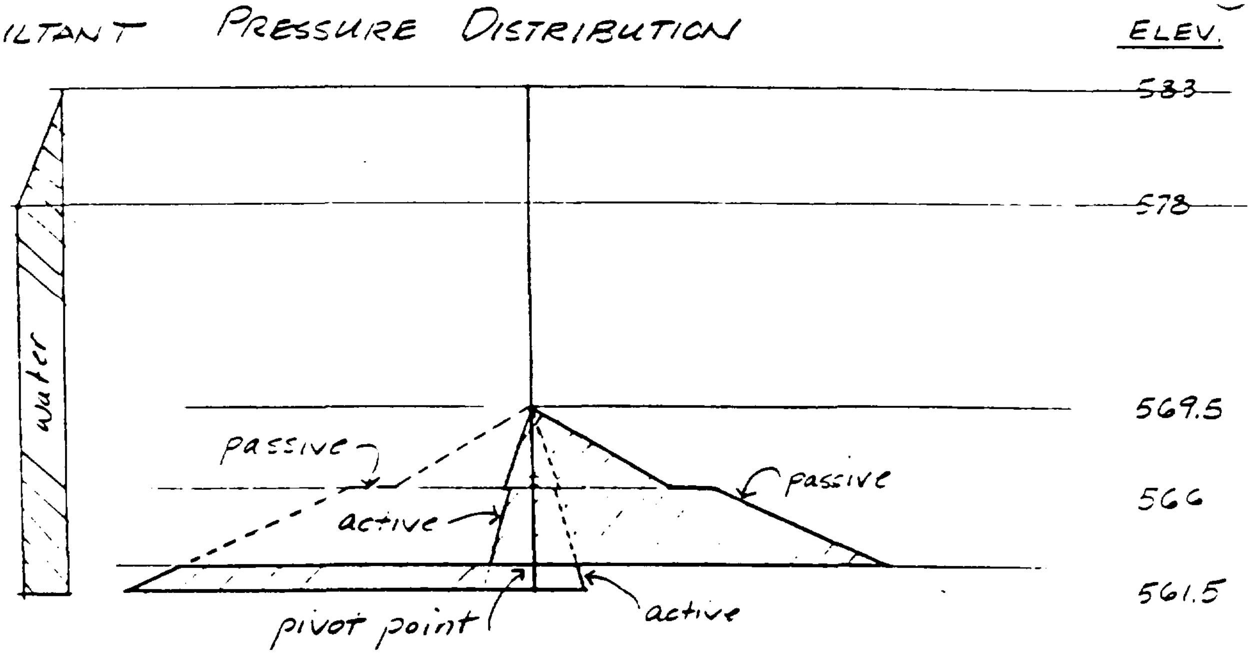
ϕ = angle of internal friction of soil = 30°
δ = angle of wall friction = 20°
β = angle of backfill = 0°

$$K_a = \frac{\cos^2 30°}{\cos 20\left(1+\sqrt{\frac{\sin(30+20)\sin 30}{\cos 20 \times \cos 0}}\right)^2} = 0.297$$

$$K_p = \frac{\cos^2\phi}{\cos\delta\left(1-\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\cos\delta\cos\beta}}\right)^2}$$

$$= \frac{\cos^2 30}{\cos 20\left(1-\sqrt{\frac{\sin(30+20)\sin(30-0)}{\cos 20\cos 0}}\right)^2} = 6.10$$

RESULTANT PRESSURE DISTRIBUTION



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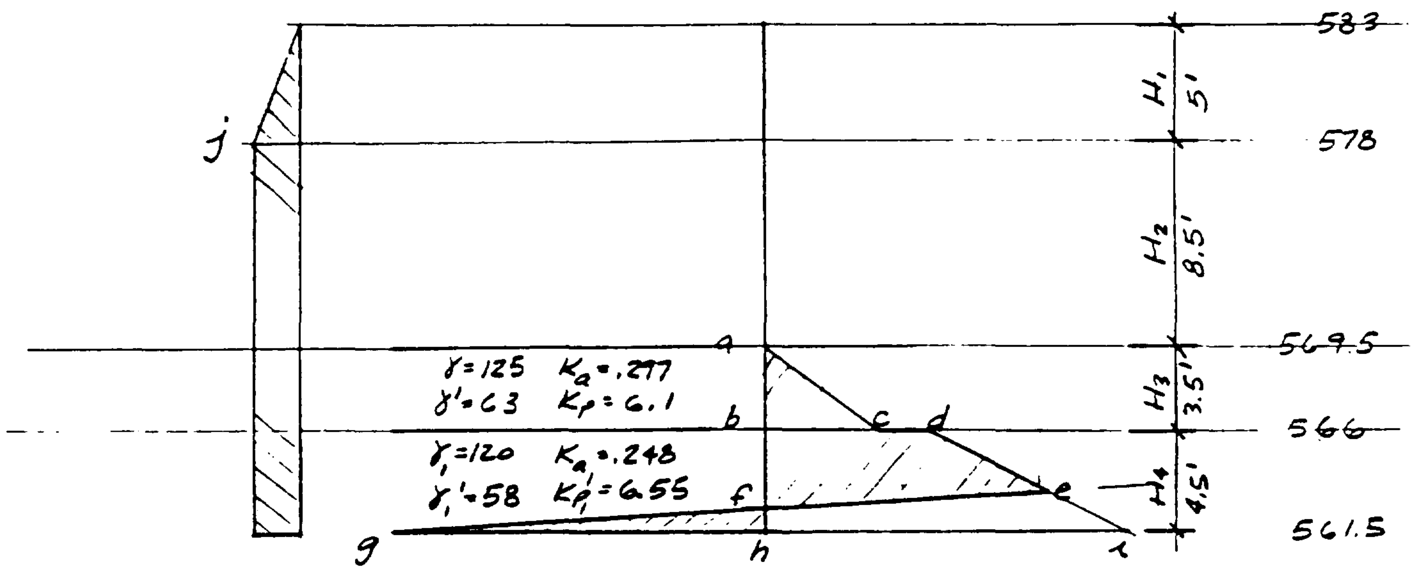
MADISON, WISCONSIN

BY RAV DATE 1-9-85 SUBJECT ACTION I - COFFERDAM DESIGN SHEET NO. 38 OF 53
CHKD. BY KN DATE 3/5/85 OMC/WAUKEGAN HARBOR JOB NO. 11837

Partial Pressure Diagram -



$$P_c = \gamma'(K_p - K_a)H_3 = 63(6.1 - .297)3.5 = 1280 \text{ \#/FT/FT}$$

$$P_d = \gamma_1'(K_{p_1} - K_{a_1})H_3 = 58(6.55 - .248)3.5 = 1280 \text{ \#/FT/FT}$$

$$P_i = P_d + \gamma_1'(K_{p_1} - K_{a_1})H_4 = 1280 + 58(6.55 - .248)4.5 = 2925 \text{ \#/FT/FT}$$

$$P_g = P_i = 2925 \text{ \#/FT/FT}$$

$$P_j = \gamma_w H_1 = 62.5 \times 5 = 313 \text{ \#/FT/FT}$$

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BY RAN DATE 1-9-85 SUBJECT ACTION I - COFFERDAM DESIGN SHEET NO. 39 OF 53
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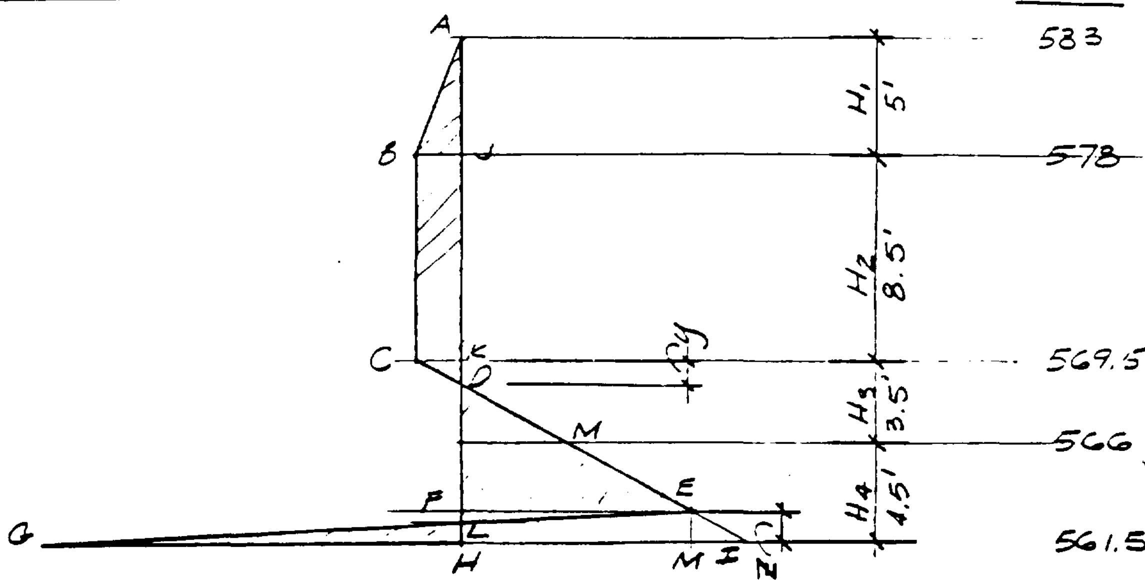
FINAL PRESSURE DIAGRAM



$P_B = P_J = 313$ #/FT/FT

$P_C = P_J = 313$ #/FT/FT

$P_M = P_d - P_j = 1280 - 313 = 967$ #/FT/FT

$P_I = P_i - P_j = 2925 - 313 = 2612$ #/FT/FT

$P_G = P_g + P_j = 2925 + 313 = 3238$ #/FT/FT

$$y = \frac{P_c}{\gamma'(K_p - K_a)} = \frac{313}{63\,(6.1 - .297)} = 0.856'$$

$\Sigma F_H = 0$

Area (ABCD) − Area (DEF) − Area (EFHI) + Area (EGI) = 0

$$P_B \times H_1 \times 1/2 + P_b \times H_2 + P_c \times y \times 1/2 - P_I \times (H_3 + H_4 - y) \times 1/2$$

$$+ (P_G + P_I) \times Z \times 1/2 = 0$$

$313 \times 5 \times 1/2 + 313 \times 8.5 + 313 \times .856 \times 1/2 - 2612(3.5 + 4.5 - .856)1/2$

$+ (2612 + 3238) \times Z \times 1/2 = 0$

$783 + 2660 + 134 - 9330 + 2925 Z = 0$

$\therefore Z = \frac{5753}{2925} = 1.967'$

Sum moments about the bottom ; $\Sigma M @ H = 0$

Area	Force	Arm	Moment
ABJ	783	18.17'	14227
BCKJ	2660	12.25'	32585
CKD	134	7.71'	1033
DHI	-9330	2.381'	-22215
EGI	2925 Z	Z/3	975 Z^2

$\Sigma M @ H = 25630 + 975 Z^2 = 0$ N.G.

<u>Try 5' of fill material</u>

$P_I = 58(6.55 - .248)5 + 63(6.1 - .297)4.5 - 313 = 3160$ #/Ft/Ft

$P_G = 58(6.55 - .248)5 + 63(6.1 - .297)4.5 + 313 = 3786$ #/Ft/Ft

$\Sigma F_H = 0$; See pg 39 for formula

$313 \times 5 \times 1/2 + 313 \times 7 + 313 \times .856 \times 1/2 - 3160(5 + 4.5 - .856) \times 1/2$

$+ (3160 + 3786) \times Z \times 1/2 = 0$

$783 + 2191 + 134 - 13658 + 3473 Z = 0$

$\therefore Z = \frac{10550}{3473} = 3.038'$

$\Sigma M @ H = 0$

Area	Force	Arm	Moment
ABJ	783	18.17'	14227
BCKJ	2191	13'	28483
CKD	134	9.215'	1235
DHI	-13658	3.072'	-41957
EGI	3473z	z/3	1157.7 z^2

$\therefore \Sigma M @ H = 1988 + 1157.7z^2 = 0$ N.G.

Try 6' of fill material

$P_I = 58(6.55-.248)\times 6 + 63(6.1-.297)4.5 - 313 = 3525$ #/FT/FT

$P_G = 58(6.55-.248)\times 6 + 63(6.1-.297)4.5 + 313 = 4151$ #/FT/FT

$\Sigma F_H = 0$; See pg. 39

$313\times 5\times 1/2 + 313\times 6 + 313\times .856\times 1/2 - 3525(6+4.5-.856)1/2$

$+(4151+3525)\times z \times 1/2 = 0$

$783 + 1878 + 134 - 16998 + 3838z = 0$

$\therefore z = \frac{14203}{3838} = 3.7'$

$\Sigma M @ H = 0$

Area	Force	Arm	Moment
ABJ	783	18.17	14227
BCKJ	1878	13.5'	25353
CKD	134	10.215	1369
DHI	-16998	3.215	-54643
EGI	3838z	z/3	1279.3 z

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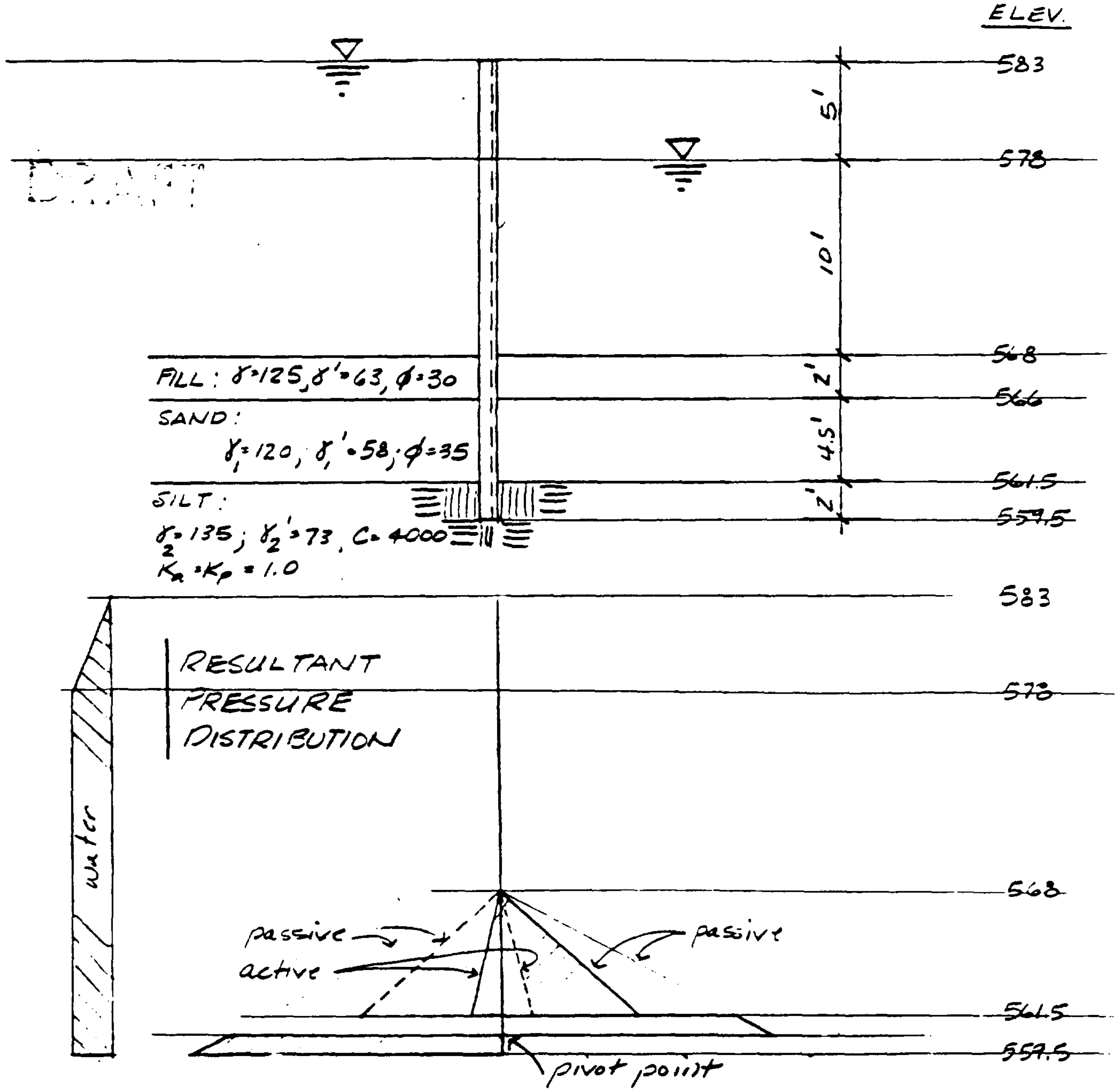
$\Sigma M @ H = -13694 + 1279.3\, z^2 = 0$; $z^2 = \dfrac{13694}{1279.3}$ $\therefore z = 3.27'$

$3.27' < 3.7'$ $\therefore$ Greater embedment req'd.

It is apparent that a significant amount of fill material would be required to achieve satisfactory stability for the cantilevered wall. Therefore, lets take advantage of the apparent ability to penetrate a nominal 2' distance into the hard silt.



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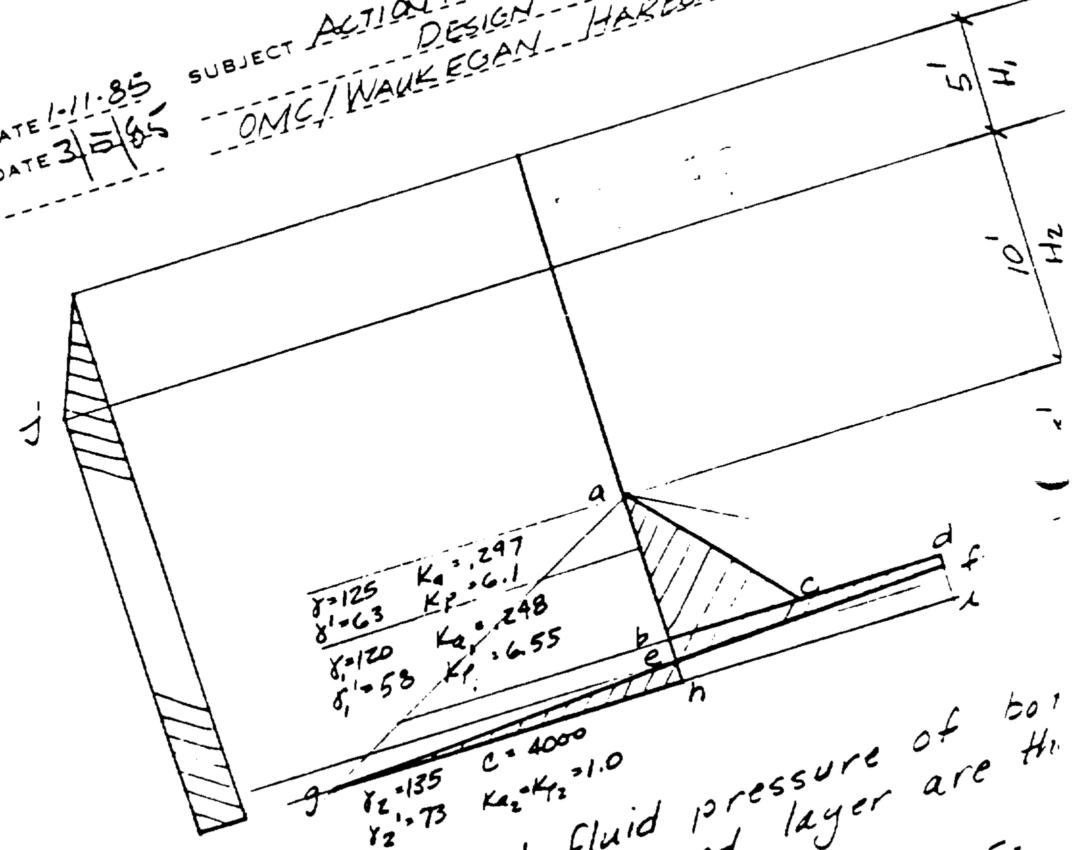
SHEET NO 43 OF 5
JOB NO. 11337

SUBJECT ACTION 1 - COFFERDAM DESIGN
OMC/WAUKEGAN HARBOR

BY RAJ DATE 1-11-85
CHKD. BY KJN DATE 3/5/85



Note: Equivalent net fluid pressure of bo[t]
fill lager and sand layer are th[e]

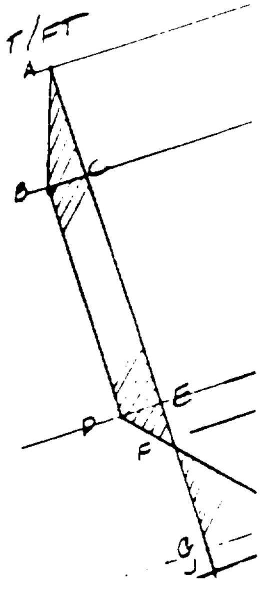
$P_c = \gamma_1'(K_{p_1} - K_{a_1})H_3 = 58(6.55 - .248) \times 6.5 =$

$P_d = 4C - \Sigma\gamma H = 4 \times 4000 - 0 = 16000$ #/F

$P_g = 4C + \Sigma\gamma H = 4 \times 4000 + 0 = 16000$ #/F

$P_j = \gamma_w H_1 = 62.5 \times 5 = 313$ #/FT/FT

FINAL LATERAL PRESSURE DIAGRAM



$P_B = P_J = 313$ #/FT/FT

$P_H = P_c - P_J = 2376 - 313 = 2063$ #/FT/FT

$P_I = P_d - P_J = 16000 - 313 = 15687$ #/FT/FT

$P_L = P_d + P_J = 16000 + 313 = 16313$ #/FT/FT

$$y = \frac{P_c}{\gamma'(K_p - K_a)} = \frac{313}{63\,(6.1 - .297)} = 0.856'$$

$\Sigma F_H = 0$

Area (ABDF) − Area (FGH) − Area (GINM) + Area (KLN) = 0

$P_B \times H_1 \times 1/2 + P_B \times H_2 + P_E \times y \times 1/2 - P_H (H_3 - y) \times 1/2 - P_I \times 2$

$+ (P_I + P_L) \times Z \times 1/2 = 0$

$313 \times 5 \times 1/2 + 313 \times 10 + 313 \times .856 \times 1/2 - 2063 (6.5 - .856) 1/2$

$- 15687 \times 2 + (15687 + 16313) \times Z \times 1/2 = 0$

$783 + 3130 + 134 - 5822 - 31374 + 16000 Z = 0$

$$Z = \frac{33149}{16000} = 2.07' > 2' \quad \therefore \text{N.G.}$$

ΣM @ Bottom $= 0$

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Area	Force	Arm	Moment
ABC	783	20.17	15791
BCED	3130	13.5	42255
DEF	134	8.5 - .856×1/3 = 8.215	1101
FGH	-5822	(6.5 - .856)1/3 + 2 = 3.88	-22597
GINM	-31374	1	-31374
KLN	16000 Z	Z/3	5333.3 Z^2

ΣM @ bottom = $5176 + 5333.3 Z^2 = 0$ N.G.

Try a 3' fill depth

$P_H = 58(6.55 - .248) \times 7.5 - 313 = 2428$ #/FT/FT

$\Sigma F_H = 0$; $783 + 313 \times 9 + 134 - 2428(7.5 - .856)1/2$

$-31374 + 16000 Z = 0$; $Z = 2.222'$

ΣM @ Bottom = 0

Area	Force	Arm	Moment
ABC	783	20.17	15791
BCED	2817	14	39438
DEF	134	9.5 - .856×1/3 = 9.215	1235
FGH	-8066	(7.5 - .856) 1/3 + 2 = 4.215	-33998
GINM	-31374	1	-31374
KLN	16000 Z	Z/3	5333.3 Z^2

$\therefore \Sigma M = -8908 + 5333.3 Z^2 = 0$ $\therefore Z = 1.29' < 2.23'$ $\therefore$ N.G.

Therefore, it appears that fill depth is greater than 3' and that full passive resistance of the silt is not developed above the point of rotation
Therefore, $Z = 2'$ and $P_I < 15687$ #/FT/FT

Try a fill depth of 4'

$$P_H = 58(6.55 - .248)\,8.5 - 313 = 2794\ \#/FT/FT$$

$$\Sigma F_H = 0 \quad 783 + 313 \times 8 + 134 - 2794(8.5 - .856)\tfrac{1}{2}$$

$$-\left(\frac{P_I}{P_I + P_L}\right) \times Z \times \frac{P_I}{2} + \frac{P_L}{2}\left(\frac{P_L}{P_I + P_L}\right) Z = 0$$

$$Z = 2 \ ; \ P_L = 16313$$

$$\therefore -7258 - \frac{P_I^2 Z}{2(P_I + 16313)} + \frac{P_L^2 Z}{2(P_I + 16313)} = 0$$

Multiply through by $2(P_I + 16313)$

$$-14515(P_I + 16313) - P_I^2 Z + 16313^2 Z = 0$$

$$-14515\,P_I - (14515 \times 16313) - 2P_I^2 + 2(16313)^2 = 0$$

Divide by (-2)

$$P_I^2 + 7258\,P_I - 1.4772 \times 10^8 = 0$$

$$\therefore P_I = \frac{-7258 + \sqrt{7258^2 + 4 \times 1.4772 \times 10^8}}{2}$$

$$= 9055\ \#/FT/FT \quad ; \quad \frac{9055}{9055 + 16313} \times 2 = 0.7139'$$

ΣM @ bottom = 0

Area	Force	Arm	Moment
ABC	783	20.17'	15791
BCED	2504	14.5'	36308
DEF	134	10.5 - .856 × 1/3 = 10.215	1369
FGH	-10679	(8.5 - .856) 1/3 + 2 = 4.548	-48568
GIJ	-9055 × .7139 × 1/2	2 - .7139 × 1/3 = 1.762	-5695
JLM	16313 × 1.2861 × 1/2	1.2861 × 1/3	4497

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$\Sigma M = +3702$ ∴ Greater fill depth req'd.

Try a fill depth of 4.5'

$P_H = 58\,(6.55 \cdot 2.48)\,9 - 313 = 2977$ #/FT/FT

$\Sigma F_H = 0$; $783 + 313 \times 7.5 + 134 - 2977\,(9 - .856)\,\tfrac{1}{2}$

$$- \frac{P_I^2 \cancel{Z}}{\cancel{2}(P_I + P_L)} + \frac{P_L^2 Z}{2(P_I + P_L)} = 0 \qquad Z = 2\ ; \ P_L = 16313$$

$$\therefore\ -8858\,(P_I + 16313) - P_I^2 + 16313^2 = 0$$

$$P_I^2 + 8858\,P_I - 1.2158 \times 10^8 = 0$$

$$\therefore P_I = \frac{-8858 + \sqrt{8858^2 + 4 \times 1.2158 \times 10^8}}{2} = 7454 \text{ \#/FT/FT}$$

$$\therefore \frac{7454}{7454 + 16313} \times 2 = 0.627'$$

ΣM @ Bottom $= 0$

Area	Force	Arm	Moment
ABC	783	20.17	15791
BCED	2348	14.75	34633
DEF	134	$11 - .856 \times 1/3 = 10.715$	1436
FGH	−12122	$(9 - .856)\,1/3 + 2 = 4.715$	−57151
GIJ	$-7454 \times .627 \times 1/2$	$2 - .627 \times 1/3 = 1.791$	−4185
JLM	$16313 \times (2 - .627)\,1/2$	$(2 - .627)\,1/3 = .4577$	5125

$\Sigma M = -4351$ ∴ Less fill depth req'd.

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Try a fill depth of 4.2'

$P_H = 58(6.55 - .248)\,8.7 - 313 = 2867$ #/FT/FT

$\Sigma F_H = 0$; $783 + 313 \times 7.8 + 134 - 2867(8.7 - .856)\tfrac{1}{2}$

$$- \frac{P_I^2 Z}{2(P_I + P_L)} + \frac{P_L^2 Z}{2(P_I + P_L)} = 0 \qquad Z = 2,\ P_L = 16313$$

$\therefore -7886\,(P_I + 16313) - P_I^2 + 16313^2 = 0$;

$P_I^2 + 7886 P_I - 1.3747 \times 10^8 = 0$; $P_I = \dfrac{-7886 + \sqrt{7886^2 + 4 \times 1.3747 \times 10^8}}{2}$

$\therefore P_I = 8427$ #/FT/FT ; $\dfrac{8427}{8427 + 16313} \times 2 = 0.681$

ΣM @ bottom $= 0$

Area	Force	Arm	Moment
ABC	783	20.17	15791
BCED	2441	14.6	35639
DEF	134	10.7 - .856 × 1/3 = 10.415	1396
FGHI	- 11244	(8.7 - .856) 1/3 + 2 = 4.615	- 51887
GIJ	-8427 × .681 × 1/2 = -2869	2 - 1/3 × .681 = 1.773	- 5087
JLM	16313 × (2 - .681) 1/2 = 10758	(2 - .681) × 1/3 = 0.44	4734

$\Sigma M = +586$ OK

Therefore, total req'd. depth ≅ 4.2' + 4.5' + 2' = 10.7'

Allowing for safety factor d = 13'

∴ Fill depth necessary = 13 - 2 - 4.5 = 6.5'

Determine Maximum Moment & SHEET PILE SIZE

Maximum moment occurs @ point of zero shear

$\Sigma F_H = 0$; $783 + 2441 + 134 - 58(6.55 - 2.48)\, y \times y/2 = 0$

$3358 - 182.76\, y^2 = 0$; $y = 4.286'$

$M_{max} = 783 \times (5 + 7.8 + .856 + 4.286) + 2441(3.9 + .856 + 4.286)$

$+ 134(.856 \times 2/3 + 4.286) - 3358 \times 4.286 \times 1/3$

$= 31973'^{\#}$

$S_{reqd} = \frac{M}{F_b} = \frac{31973 \times 12}{25 \times 10^3} = 15.35\ in^3/FT$

By inspection use PZ27 ; $S = 30.2\ in^3/FT$

DRAFT

SUMMARY

1. Construction of the 85'ϕ cofferdam does not appear feasible because of the necessity to penetrate ~9.5' into the hardpan mat'l. Based upon our experience and conversations with contractors this does not appear realistic. pg 8 & 9

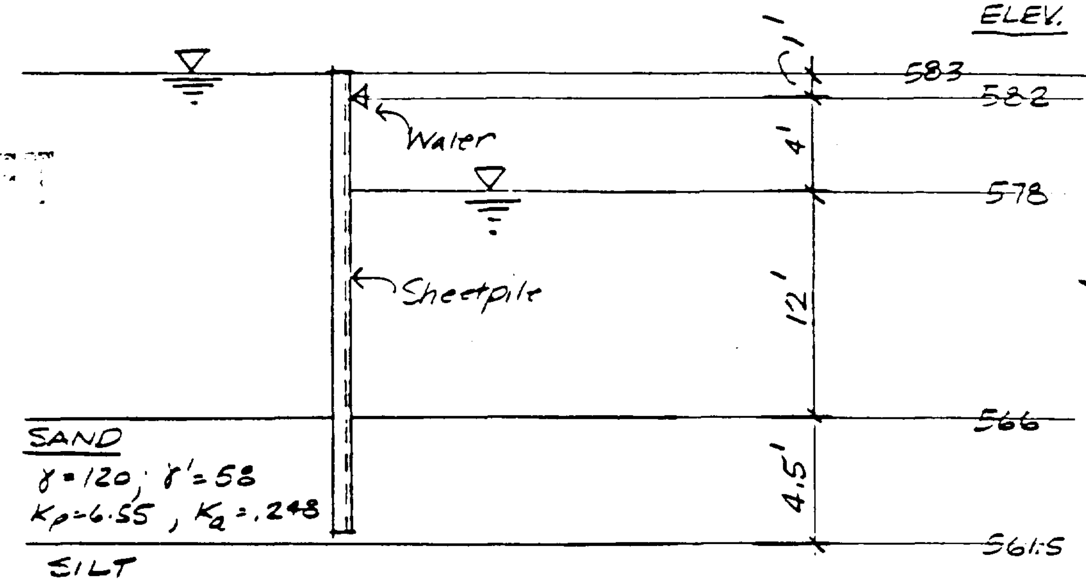
2. Initial alternative pursued providing a 105'ϕ single wall sheet pile cofferdam concentric with the 85'ϕ excavation. This results in a 10' wide berm at the interior perimeter providing toe support. Therefore, only 2' embedment into the hard silt is required. pg. 12

3. A second alternative pursued involved using the existing south and west bulkhead walls as the limits of the cofferdam on two sides. Provide

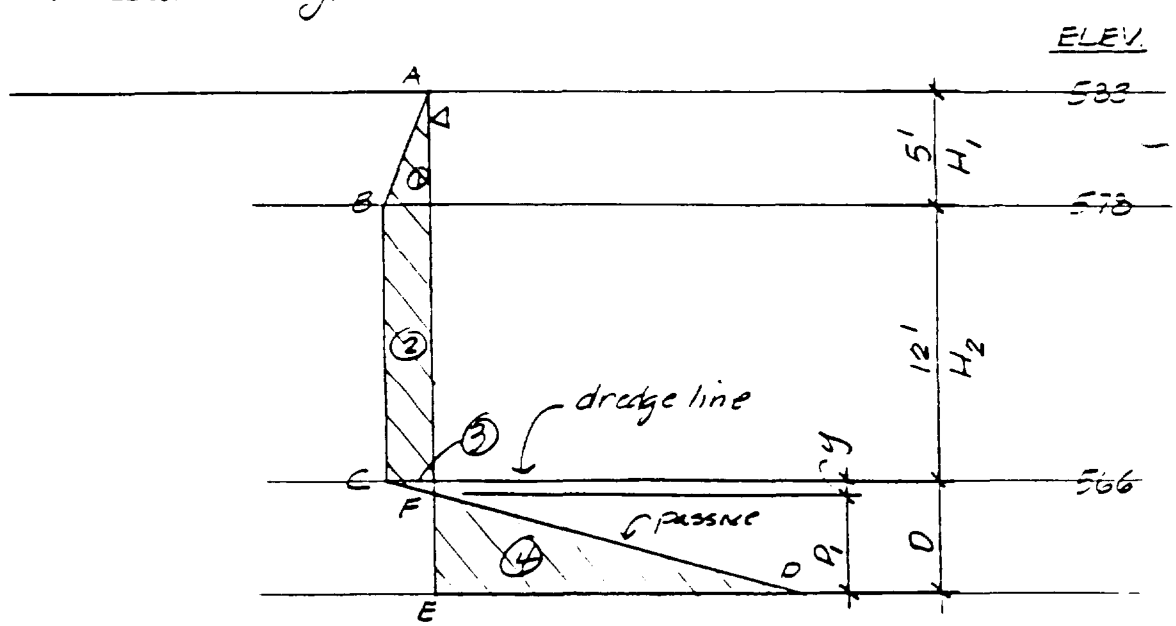
a new bulkhead wall inland along the North side as req'd. Provide a temporary bulkhead wall along the east side across slip No.3 width.

4. Advantages of the second alternative over the first are reduced cost and minimizing problems associated with dredging.

Because contamination of the cantilevered sheet pile stone fill berm is likely; thereby necessitating its removal, let's investigate bracing the top of the wall across the width of slip No. 3.



Lateral Pressure Diagram



LATERAL PRESSURES -

$P_B = \gamma_\omega H_1 = 62.5 \times 5 = 313$ #/FT/FT

$P_D = \gamma'(K_p - K_a)D - P_B = 58(6.55 - .248)D - 313 = 365.5D - 313$

Determine "y"

$$y = \frac{P_c}{\gamma'(K_p - K_a)} = \frac{313}{58(6.55 - .248)} = 0.856'$$

Sum moments about water elevation.

Mark	Force	Arm	Moment
①	$313 \times 5 \times 1/2 = 782.5$	$5 \times 2/3 - 1 = 2.333'$	1825.6
②	$313 \times 12 = 3756$	$12 \times 1/2 + 4 = 10$	37560.0
③	$313 \times .856 \times 1/2 = 134$	$.856 \cdot 1/3 + 16 = 16.285$	2182.2
④	$-(365.5D - 313)(D - .856)1/2$ $= (182.75D^2 - 156.5D - 156.4D + 134)$ $= (182.75D^2 - 313D + 134)$	$(D - .856)2/3 + 16.856 =$ $2/3 D + 16.285$	$-121.83D^3 + 208.7D^2 - 89.3D - 2976.1D^2 + 5097.2D - 2182.2$

$$\therefore \Sigma M_{TOT} = 41567.86 - 121.83D^3 - 2767.4D^2 + 5007.9D - 2182.2 = 0$$

$$-121.83D^3 - 2767.4D^2 + 5007.9D + 39385.66 = 0$$

Try $D = 3$

$-121.83(3)^3 - 2767.4(3)^2 + 5007.9(3) + 39385.66 = 26213$ N.G.

Try $D = 4'$

$-121.83(4)^3 - 2767.4(4)^2 + 5007.9(4) + 39385.66 = 7342$ N.G.

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Try $D = 4.4'$

$$-121.83(4.4)^3 - 2767.4(4.4)^2 + 5007.9(4.4) + 39395.66 = -253\,\#$$

Try $D = 4.3'$

$$-121.83(4.3)^3 - 2767.4(4.3)^2 + 5007.9(4.3) + 39395.66 = +64 \quad \underline{\underline{OK}}$$

∴ Total Penetration with safety factor = $\underline{\underline{5.25'}}$

Determine force @ waler elevation

$\Sigma F_H = 0$; $P_1 + P_2 + P_3 - P_4 = P_{waler}$ see pg 52 for values of "P"

$$\therefore P_\omega = 782.5 + 3756 + \cancel{134} - 182.75(4.3)^2 + 313(4.3) - \cancel{134}$$

$$= 2505\ \#/FT$$

Determine Maximum Moment in Piling

Maximum moment occurs @ point of zero shear. Determine location of zero shear:

Assume pt. of zero shear occurs "y" ft. below low water

$\Sigma F_H = 0$; $P_1 + P_B \times y - P_\omega = 0$

$$782.5 + 313 \times y - 2505 = 0 \quad ; \quad y = 5.5'$$

$$\Sigma M_{above\ zero\ shear} = M_{max} = P_1 \times (H_1 \times 1/3 + y) + P_B \times y^2 \times 1/2 - P_\omega (4 + y)$$

$$= 782.5(5/3 + 5.5) + 313 \times 5.5^2 \times 1/2 - 2505(4 + 5.5)$$

$$= -13456\ ^{1-\#}/FT$$

$$\therefore S_{req'd} = \frac{M}{F_b} = \frac{13456 \times 12}{25000} = 6.5\ in^3$$

By inspection use PZ27

SP 10878

Determine waler requirements

Assume waler to be laterally supported by struts @ 1/3 RD points

$\therefore M_{max} = \frac{w\ell^2}{10} = \frac{2.505^{k/FT} \times (70/3)^2}{10} = 136.4^{1\text{-}k}$

$L_{unsupported} = 0.4\ell$; from midspan inflection point to the strut.

$= 0.4 \times 70/3 = 9.33'$

$P_{axial} = 1.1\, w\ell = 1.1 \times 2.505 \times \frac{70}{3} = 64.3^{k}$ - Component from strut

Try W14x61

$A = 17.9^{\square''}$

$d/A_f = 2.15$

$S_x = 92.2\, in^3$

$r_x = 5.98\, in$

$r_y = 2.45\, in$

$\frac{K_x \ell_x}{r_x} = \frac{1.0 \times 70/3 \times 12}{5.98} = 46.8 \therefore F_a = 18.63^{ksi}$ Table 3-36 AISC

$F'_{e_x} = 68.2^{ksi}$ Table 9 AISC

$\frac{K_y \ell_y}{r_y} = \frac{1.0 \times 9.33 \times 12}{2.45} = 45.7 \therefore F_a = 18.72^{ksi}$

$f_a = \frac{P}{A} = \frac{64.3^k}{17.9} = 3.59^{ksi} \quad \therefore \frac{f_a}{F_a} = \frac{3.59}{18.63} = 0.193 > 0.15$

$f_b = \frac{M}{S} = \frac{136.4 \times 12}{92.2} = 17.75^{ksi}$

$F_b = \frac{12 \times 10^3 C_b}{\ell\, d/A_f} = \frac{12 \times 10^3}{(70/3 - 9.33) \times 12 \times 2.15} = 33.2 > .6F_y$ AISC 1.5-7

$\therefore F_b = 0.6 F_y = 22^{ksi}$

$\frac{f_a}{F_a} + \frac{C_{m_x} f_{b_x}}{(1 - \frac{f_a}{F'_{e_x}}) F_{b_x}} \le 1.0$ [AISC 1.6.1-A] ; $0.193 + \frac{17.75}{(1 - \frac{3.59}{68.2}) 22} = 1.04$ OK

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Determine Strut Requirements

$P_{norm} = 1.1 w l = 1.1 \times 2.505 \times \frac{70}{3} = 64.3^k$

$\therefore P_{axial} = \frac{64.3}{\cos 45°} = 90.9^k$ $\quad l_{unsupported} = \frac{70/3}{\cos 45°} = 33'$

By inspection provide W 10x54, AISC Column selection Table pg 3-27

Check waler web crippling @ interior strut location

$R_{max} = 0.75 F_y t (N + 2k)$, $N = 10''$ $t_w = .375''$, $k = 1.4375''$

$= .75 \times 36 \times .375 (10 + 2 \times 1.4375) = 130.4^k > 64.3^k \quad \therefore$ OK

Bearing PL Requirements

Assume $10\frac{1}{2}'' \times 10\frac{1}{2}''$ $\therefore$ $f_{brg} = \frac{64.3}{10.5^2} = 0.583^{ksi}$

$n = [10.5 - (.8 \times 10.03)] \times \frac{1}{2} = 1.238''$ ← Controls $\therefore t_{reqd} = 1.238 \sqrt{\frac{.583}{.25 \times 36}}$

$m = [10 - (.95 \times 10.09)] \times \frac{1}{2} = 0.457''$ $\quad = 0.32''$

$\therefore$ Provide $10\frac{1}{2}'' \times \frac{3}{8}'' \times 0'-10\frac{1}{2}''$ Bearing PL

SLIP NO. 3 COFFERDAM SUMMARY

I. Materials
  A. East end temporary closure wall
    1. PZ 27 Sheetpile
      a. Top/sheetpile elevation = 583
      b. Pile tip elevation = 560.5
    2. W 14x61 Waler
    3. W 10x54 Strut w/ 10½" x ⅞" x 10½" Bearing ℄

  B. Temporary bulkhead wall
    1. PZ27 Sheetpile
      a. Top/sheetpile elevation = 583
      b. Pile tip elevation = 560.5
    2. (2) - C 10x20 Waler
    3. 30^k Capacity grouted earth anchors @ 10' % Max.

  C. Permanent bulkhead wall
    1. PDA 27 Sheetpile
      a. Top/Sheetpile elevation = 583
      b. Pile tip elevation = 560.5
    2. (2) - C10x20 Waler
    3. 30^k Capacity grouted earth anchors @ 10' % Max.

II. Excavation
  A. Between existing and temporary bulkhead walls to top of sand layer
    1. Temporary bulkhead wall radius = 55'
    2. Angle inscribed by temporary bulkhead = $\left(180 - 2 \times \text{invsin} \frac{18}{55}\right) = 141.8°$
    3. Chord length inscribed by temp. bulkhead = $\sin\left(\frac{141.8}{2}\right) \times 55 \times 2 = 104'$
    4. Depth to top of sand = 16'

5. Volume = $(\pi \times 55^2 \times \frac{141.8°}{360} - 18 \times 104 \times 1/2) \times 16 \times 1/27 = 1664$ CY

B. Sand excavation
1. Diameter = 95' - accounts for material seeking angle of repose
2. Depth = 5'
3. Volume = $\pi \times 95^2 \times 1/4 \times 5 \times 1/27 = 1313$ CY

DRAFT

C. Silt excavation
1. Diameter = 85'
2. Depth = 4.5'
3. Volume = $\pi \times 85^2 \times 1/4 \times 4.5 \times 1/27 = 946$ CY

D. Method - Excavation of the material will be accomplished with a clamshell bucket from shore. At the proper stage, excavation will be backfilled with imported fill material.

III. Procedure
A. Install east end closure wall
B. Clamshell dredge sediments
C. Temporarily brace existing bulkhead across slip width.
D. Install temporary bulkhead wall
E. Excavate material btwn. existing & temporary bulkhead walls.
F. Remove temporary bracing & exstg. bulkhead wall
G. Excavate deep sand & silt
H. Backfill excavation.
I. Install new bulkhead wall and temporarily brace across slip width.
J. Backfill between temporary and new bulkhead walls,
K. Remove temporary bulkhead wall
L. Install waler & tiebacks for new bulkhead wall

M. Remove bulkhead wall temporary bracing
N. Remove east end closure wall

IV. Removal

A. All sheetpile, walers, struts, etc. utilized to facilitate this construction activity shall be decontaminated upon removal and transported from the site.

DRAFT

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

I-63

BY R. WEBER DATE 12-19-84 SUBJECT OMC - WAUKEGAN HARBOR SHEET NO. I-63 OF ____
CHKD. BY W. WURLMER DATE 2-21-85 JOB NO. C11937
SLIP No. 3 BORINGS

4. SLIP NO 3 SOIL BORINGS.

REFERENCES: ① WARZYN ENGINEERING REPORT, "SAND SAMPLE COLLECTION, WAUKEGAN HARBOR SLIP #3, WAUKEGAN, ILLINOIS," DATED JANUARY 6, 1981, WARZYN JOB No. C9560, B1 TO B6.

② WARZYN ENGINEERING REPORT, "SEDIMENT AND SHORE SAMPLE COLLECTION, WAUKEGAN HARBOR SLIP #3, WAUKEGAN, ILLINOIS," DATED MAY 26, 1981, WARZYN JOB No. C9720, B7 TO B12.

BORING	SAMPLE NO.	USGS[a] ELEV.	SOIL TYPE	SPT N-VALUE	NATURAL MOISTURE (%)	DRY DENSITY (PCF)
B1	TOP OF LAYER	570.2	MUCK	-		
	"	565.8	SAND	-		
	"	563.2	CLAY	-		
B1	1	565.0	SAND	14	10.2	
	2	562.0	CLAY	33		
B2	TOP OF LAYER	572.7	MUCK	-		
	"	568.5	SAND	-		
	"	563.0	CLAY	-		
B2	1	566.7	SAND	15	22.5	
	2	564.2	SAND	13	22.7	
	3	561.7	CLAY	28		
B3	TOP OF LAYER	571.0	MUCK	-		
	"	568.2	SAND	-		
	"	562.2	CLAY	-		
B3	1	567.2	SAND	10	23.9	
	2	565.2	SAND	27	23.8	
	3	561.7	CLAY	32		
B4	TOP OF LAYER	573.3	MUCK	-		
	"	569.3	SAND	-		
	"	561.3	CLAY	-		
B4	3	563.8	SAND	28		
	5	561.3	SAND	72 (GRAVEL)	11.3	
	6	559.8	CLAY	60		
B5	TOP OF LAYER	570.8	MUCK	-		
	"	570.3	SAND	-		
	"	568.5	CLAY	-		

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY RHWEBER DATE 12-19-84 SUBJECT OMC SHEET NO. I-69 OF 6
CHKD. BY NW DATE 2-27-85 JOB NO. 11837

BORING	SAMPLE NO.	USGS ELEV.	SOIL TYPE	SPT N-VALUE	NATURAL MOISTURE (%)	DRY DENSITY (PCF)
B5	NO SPT SAMPLES			–		
B6A	TOP OF LAYER	573.6	MUCK	–		
	"	569.5	SAND	–		
	"	562.1	CLAY	–		
B6A	1	568.6	SAND	16	24.2	
	2	566.6	SAND	22		
	3	564.1	SAND	39	23.8	
	4	561.6	SAND	31		
B7	TOP OF LAYER	568.7	MUCK	–	136.1	29.1
	"	566.9	SAND	–		
	"	560.6	CLAY	–		
B7	1	560.6	SAND	43		
	2	559.1	CLAY	37		
	3	557.6	CLAY	21		
	4	556.1	CLAY	83		
	5	554.6	SILT	110		
B8	TOP OF LAYER	568.0	MUCK	–	148.6	26.9
	"	565.1	SAND	–		
	"	559.9	CLAY	–		
B8	1	560.4	SAND	15		
	2	558.4	CLAY	39		
	3	555.3	CLAY	29		
	4	551.4	CLAY	85		
B9	TOP OF LAYER	573.3	MUCK/SAND	–	41.5	48.7
	"	564.1	SAND	–		
	"	560.2	CLAY	–		
B9	1	571.4	MUCK/SAND	0		
	2	565.4	MUCK/SAND	1		
	3	560.4	SAND	7		
	4	558.9	CLAY	79		
	5	555.4	CLAY	80		
	6	553.9	CLAY	63		
B10	TOP OF LAYER	582.0	GRAVEL FILL	–		
	"	574.5	SAND	–		
	"	561.5	CLAY	–		

SP 102976

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 12-20-84 SUBJECT OMC SHEET NO. I-70 OF
CHKD. BY WW DATE 2-27-85 JOB NO. C11837

BORING	SAMPLE NO.	USGS ELEV.[a]	SOIL TYPE	SPT N-VALUE	NATURAL MOISTURE (%)	DRY DENSITY (PCF)
B10	1	579.5	GRAVEL FILL	16		
	2	568.5	SAND	2		
	3	561.0	CLAY	37		
	4	557.0	CLAY	63		
B11	TOP OF LAYER	582.1	GRAVEL FILL	-		
	"	581.6	SAND	-		
	"	561.1	CLAY	-		
B11	1	578.6	SAND	7		
	2	567.1	SAND	25		
	3	564.6	SAND	13		
	4	562.1	SAND	11		
	5	559.6	CLAY	61		
	6	557.1	CLAY	59		
B12	TOP OF LAYER	582.3	GRAVEL FILL	-		
	"	576.3	SAND	-		
	"	571.3	PEAT/WOOD	-		
	"	569.3	ORGANIC SILT	-		
	"	566.8	SAND	-		
	"	561.8	CLAY	-		
B12	1	579.8	GRAVEL FILL	7		
	2	567.3	PEAT/WOOD	9		
	3	564.8	SAND	5		
	4	561.3	CLAY	30		
	5	557.3	CLAY	39		

NOTE: (a) ELEVATION OF BENCHMARK FOR B1 TO B6 WAS OBTAINED FROM MASON & HANGER DRAWINGS, "DREDGING AND WATER TREATMENT FOR REMOVAL OF PCB CONTAMINATION IN WAUKEGAN HARBOR, WAUKEGAN, ILLINOIS, UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION V, CHICAGO, ILLINOIS," SHEET No. C-5, "COFFERDAM," DATED 9/1/81. SURFACE ELEVATION AT B10, B11 AND B12 WERE OBTAINED FROM THIS SAME DRAWING.

SUMMARY OF SPT N-VALUES (BLOWS PER FOOT)

LAYER	NUMBER OF VALUES	LOW	HIGH	MEAN	STANDARD DEVIATION
GRAVEL FILL	2	7	16	11.5	6.4
MUCK	2	0	1	0.5	0.7
SAND	20	2	72	21.0	16.4
CLAY	19	21	85	50.4	21.1

CORRELATE SPT N-VALUES TO SOIL INDEX PROPERTIES

REFERENCE: BOWLES, J.E., "FOUNDATION ANALYSIS AND DESIGN," 2ND EDITION, MCGRAW HILL, NEW YORK, 1977.

GRAVEL FILL: TABLE 3-3, p. 85.
$\bar{N}$ = 11.5 BLOWS/FOOT → LOOSE TO MEDIUM DENSE
USE $\phi = 31°$ AND $\gamma_{MOIST} = 110$ PCF ✓

MUCK: TABLE 3-4, p. 86.
$\bar{N}$ = 0.5 BPF → VERY SOFT
USE $q_u = 0.1$ ksf, $C = \frac{1}{2} q_u = 0.05$ ksf = 50 PSF, $\phi = 0°$ SINCE SATURATED
$\gamma_{MOIST} \sim 95$ PCF
FROM B7 – $\gamma_{MOIST} = \gamma_{DRY} \times (1+w) = 29.1 (2.361) = 69$ PCF ✓
B8 – $\gamma_{MOIST} = 26.9 (2.486) = 67$ PCF ✓
USE $\gamma_{MOIST} = 68$ PCF

SAND: TABLE 3-3, p. 85.
$\bar{N}$ = 21.0 BPF → MEDIUM DENSE
USE $\phi = 35°$ AND $\gamma_{MOIST} = 120$ PCF ✓

CLAY: TABLE 3-4, p. 86.
$\bar{N}$ = 50.4 BPF → HARD
SINCE OFF THE CHART, TO BE CONSERVATIVE, USE $q_u = 8.0$ ksf,
$C = \frac{1}{2} q_u = 4$ ksf = 4000 PSF, $\phi = 0°$ SINCE SATURATED,
$\gamma_{MOIST} = 135$ PCF ✓

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY ~~ KH ~~ DATE 12-20-84 SUBJECT SMC SHEET NO. I-72 OF
CHKD. BY WW DATE 2-27-85 JOB NO. C11837

FROM PAGES 1, 2 AND 3

AVG. GROUND SURFACE ELEV. (B10, B11, B12) = 582.1 SAY 582
ASSUME G.S. EQUALS TOP OF SHEET PILE WALL

AVG. TOP OF MUCK ELEV. (B1 TO B9) = 571.3 SAY 571

AVG. TOP OF SAND ELEV. (B1 TO B9) = 567.5 SAY 567

AVG. TOP OF CLAY ELEV. (B1 TO B12) = 562.1 SAY 562

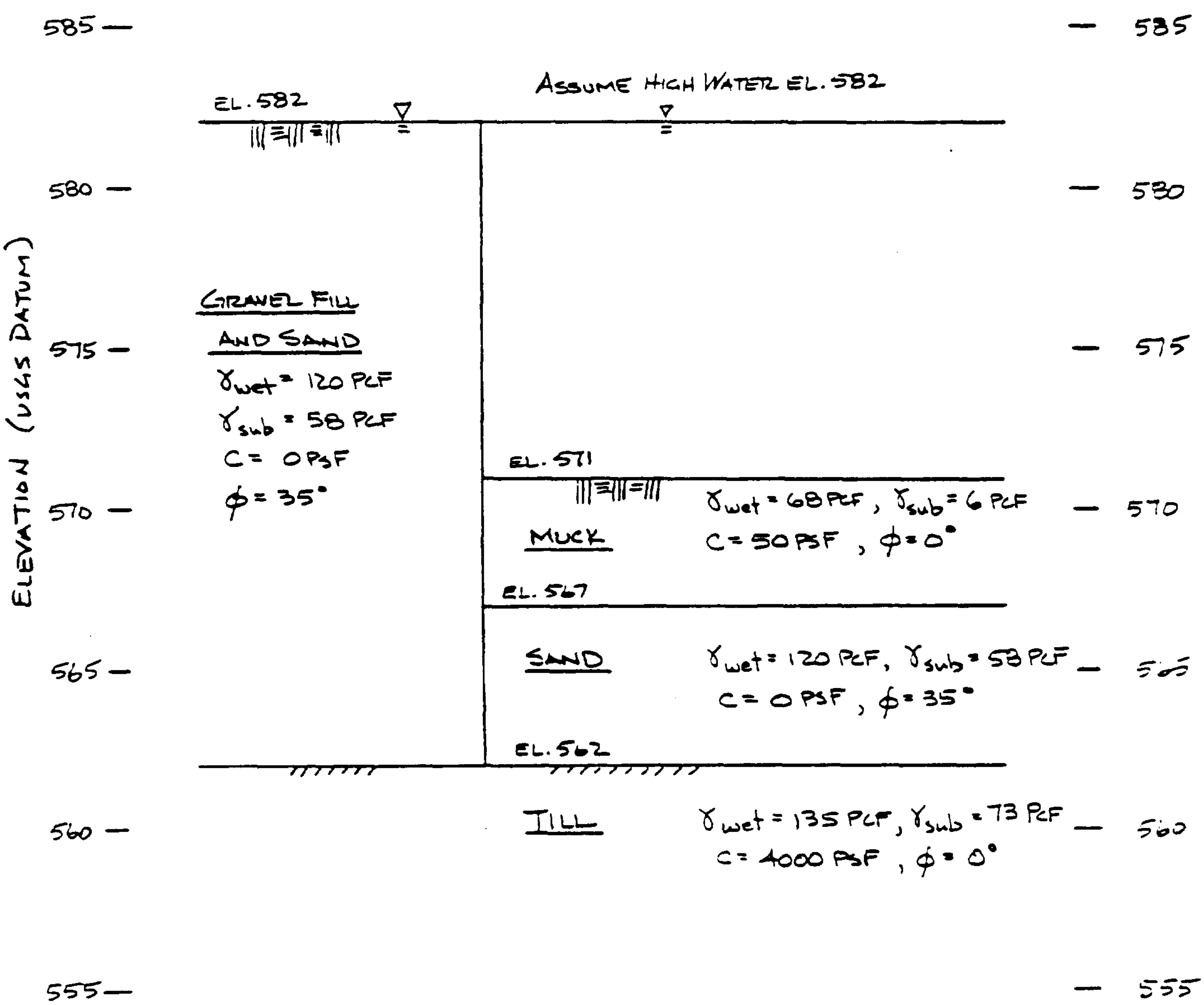
CH2M HILL CONCEPTUAL DESIGN REPORT DATED 9/14/84 STATES THAT HARBOR SHEETING VARIES FROM 20 TO 25 FT. IN LENGTH. ASSUME THAT SHEETING IN SLIP NO. 3 EXTENDS TO CLAY WITH LITTLE OR NO PENETRATION. THEREFORE, EL. 582 - 562 = 20 FT. GOOD CORRELATION.

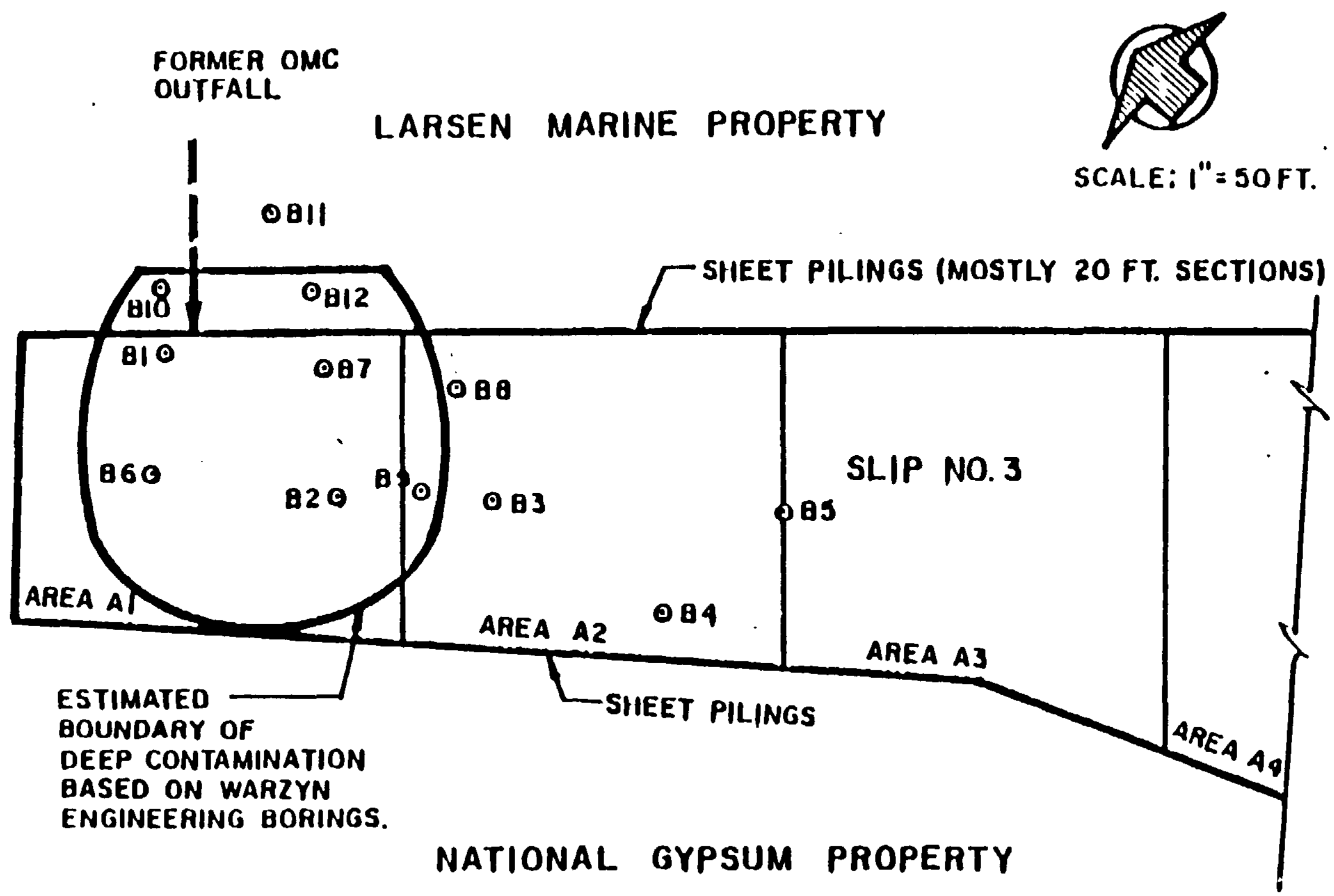
SINCE SAND HAS GREATER UNIT WEIGHT AND FRICTION ANGLE THAN GRAVEL FILL BEHIND THE BULKHEAD (SEE PAGE 4), USE SAND PARAMETERS AS BEING CONSERVATIVE FOR DETERMINING LATERAL EARTH PRESSURES.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY [illegible] DATE 12-20-84 SUBJECT OMC SHEET NO. I-73 OF
CHKD. BY WW DATE 2-27-85 JOB NO. C11837

TYPICAL SECTION AT SLIP No. 3 (WEST END) 1" = 5'





⊙ BORINGS B1 THRU B6 NOVEMBER 19 - 22, 1980.
⊙ BORINGS B7 THRU B12 MARCH 16 - 20, 1981.

NOTE:
PCB ANALYSES PRESENTED IN FIGURES 2 AND 3.

FIGURE 1
LOCATION OF CORE BORINGS IN NORTHWEST END OF SLIP NO. 3

FROM M-H ADDENDUM TO FINAL REPORT, MAY 81.

5

I-74

I. Area A, Slip 3, Upper Waukegan Harbor

Site Construction

D. Hopper

A hopper will be provided to direct dredging from the clam shell bucket into the truck with minimal spillage. The hopper will not be designed to retain any dredging. The hopper will include a splash curtain and drip tray to further isolate the truck body from potential contamination. The hopper will include vibration device to provide for positive removal of solids from the hopper to the truck.

The hopper will include a removable screen basket to screen potential debris picked up by the clamshell bucket. The debris collected in the screen basket would be manually removed and collected for proper disposal. Disposal will be made in the parking lot containment area.

MABS/BL1

I. Area A, Slip 3, Upper Waukegan Harbor

Site Construction

E. Water Intake Reconstruction Alternatives

The Conceptual Design (CH2M Hill, 9-14-84) calls for relocating the existing OMC intake within Slip 3. This approach is considered unacceptable because it would allow the intake of contaminated water caused by disturbance of the harbor bottom during dredging operations.

In order to provide uncontaminated water to OMC during the harbor cleanup, three alternative plans are being considered. The first alternative consists of handling OMC's intake water needs by connection to the existing City of Waukegan 24-inch water main in the area. The second alternative consists of a temporary pump station and an above-ground water intake line from Slip 1. The third alternative provides for extending the existing gravity intake to Slip 1.

The following discussion is on the technical and financial considerations relative to each alternative. Until confirming and additional information on the site, soil characteristics, the existing OMC intake, other site utilities, OMC's water system and water demands, etc. are obtained, the discussion of these alternatives shall be considered preliminary in nature.

Alternative No. 1 - Connect to City's Existing Potable Water Main

The City of Waukegan Water Utility has an existing 24-inch potable water main which crosses the area between the existing OMC intake at Slip 3 and the OMC plant. OMC could be provided with water during harbor cleanup operations by connecting to this existing water main.

Per discussions with the City, the water main system pressure is 80-85 psi. The Water Utility treatment plant is located just a short distance from OMC at the tip of the peninsula in Waukegan Harbor.

In previous discussions with OMC, the City was informed that OMC's peak demand on their water intake is approximately 96,000 gallons per hour. This flow was identified with the months of August and September. The City has no information relating to the breakdown of this figure regarding constant and average flows or daily or monthly fluctuations. The

City noted they requested this additional information, but OMC has refused to provide it. However, the City foresees no difficulty in supplying OMC with water based on the peak figure available.

Considering the convenient location of the water main and the City's ability and willingness to supply water to OMC, this alternative appears to be technically feasible.

The City has provided us with their connection fee and water rate schedule. In order to use their information and establish a final construction and service cost for this alternative, additional information on OMC water demands, including total monthly consumption, must be obtained. A large portion of the total cost for implementing this alternative will be due to water consumption costs.

Costs for connection to the existing water system (including tapping valve, sleeve, water meter, and backflow preventor) would be significantly less than any other alternative that requires a lengthy extension of intake piping. Additional costs may be incurred; however, if any required revisions to the OMC's intake water collection and distribution system are needed. It is probable that OMC's existing system utilizes pumps to distribute water through the plant. Therefore, some modifications to handle City water system pressures may be required to OMC's internal piping and equipment. More information is needed to establish what modifications may be required.

The financial feasibility of this alternative can only be definitively determined after obtaining and analyzing the information identified previously. Considering the relatively short duration of the harbor dredging operations and the piping lengths associated with the other alternatives, it is quite possible this alternative could prove to be the most economical. For this reason, a preliminary cost estimate for implementing only this alternative has been provided.

Alternative No. 2 - Intake Piping Extension to Slip 1 Utilizing a Pump Station

In lieu of trenching an extended gravity intake line from OMC to Slip 1 a temporary line could be laid above ground. For purposes of this discussion, the alignment for the temporary line was assumed along Sea Horse Drive.

This alternative would eliminate the need for most trench excavation and dewatering along the pipe alignment. A pump station would be required at Slip 1 to collect water from within the Slip and pump it to OMC. Based on 96,000 gph, a 12 inch diameter pressure main would probably be required to avoid excessive head losses. Similar to Alternative 1, some modifications to OMC's internal piping and equipment may be required.

Considering the short duration of the harbor cleanup, the construction of a 96,000 gph pump station (with the necessary control system) does not seem prudent. The cost for the pump station alone may make this alternative more expensive than the other alternatives.

Additional information required to further evaluate this alternative includes OMC water demand variations, internal OMC equipment and distribution system, and utility information along the proposal route. Property or easement acquisition would probably be required.

Alternative No. 3 - Intake Piping Extension to Slip 1 Below Lake Level

The third alternative reviewed provides for extension of a buried gravity intake pipe along Sea Horse Drive to Slip 1. For the purpose of this discussion, a 24-inch diameter line size was assumed. Based on a 96,000 gph flow rate a 24-inch diameter gravity line is of sufficient size to result in only minimal head losses. The 24-inch diameter line would connect into the existing OMC intake and require no revisions to OMC's internal piping and equipment.

The line would extend to Slip 1 at an elevation below the recorded low lake level in order to assure gravity intake. Required trench depth would be approximately 12 feet. As the line would be installed below lake level trench dewatering would be required.

Technically this alternative appears feasible; however, due to the trench depth associated with this approach, concerns relating to trench stability, dewatering, and conflicts with existing utilities and structures would have to be addressed. These items would also affect the financial feasibility of this alternative, as would acquisition of any necessary easements or property.

Summary

From a general overview, Alternative No. 1, connecting to the existing City water main, appears to be the most technically feasible of all intake relocation alternatives.

Additional information is required to confirm the feasibility of several items under all three alternatives.

A comparison of costs associated with the different alternatives would be premature at this time. The biggest factors affecting alternative costs is OMC water consumption volumes and soil stability and dewatering characteristics. Easement and property acquisition needs could also impact on feasibility. However, for this 30 percent conceptual design, it is being assumed that Alternative No. 1 could prove to be the most economical. A preliminary cost estimate for Alternative No. 1 has been provided accordingly.

MABS/BJO

SITE RESTORATION

WARZYN
ENGINEERING INC

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 2-22-85 SUBJECT DESIGN REQUIREMENTS SHEET NO. I-30 OF
CHKD. BY DJD DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11637

SITE RESTORATION

I AREA A

A. BACKFILLING DEEP EXCAVATION

1. Volume

The volume to be backfilled in the deep excavation is 3,923 cy as determined under Site Construction, (B), 2 - Volume of Sand & Silt.

I. AREA A, SLIP 3, UPPER WAUKEGAN HARBOR

SITE RESTORATION

A. BACKFILLING DEEP EXCAVATION

2. GRADATION

THE DEEP EXCAVATION WILL INCLUDE REMOVAL OF THE UPPER ORGANIC SILT (MUCK), THE MIDDLE SAND AND A PORTION OF THE LOWER TILL. BACKFILLING WILL OCCUR PRIOR TO PULLING SHEETING. TO MINIMIZE POTENTIAL DIFFICULTIES IN PLACING BACKFILL INSIDE THE COFFERDAM THAT WILL NOT BE DEWATERED, A GRANULAR BACKFILL MATERIAL WILL BE SPECIFIED. THE BACKFILL SHOULD CONTAIN ENOUGH LARGE PARTICLES TO EXPEDITE SETTLING OUT TIME AND TO SETTLE INTO A RELATIVELY DENSE STATE, BUT NOT CONTAIN TOO LARGE OF PARTICLES SUCH THAT VOIDS IN THE BACKFILL EXIST FOR SAND OUTSIDE THE COFFERDAM THAT IS NOT REMOVED TO WASH INTO THE VOIDS AND LESSEN THE TOE STABILITY OF THE BULKHEAD. THE BACKFILL SHOULD CONTAIN ENOUGH SMALL PARTICLES TO ACT AS FILTER TO THE SAND, BUT NOT CONTAIN SO MANY FINES THAT SEVERE WATER TURBIDITY IS CAUSED DURING BACKFILLING.

BASED ON THE COARSE AGGREGATE GRADATIONS LISTED ON PAGE 546 OF THE ILLINOIS DOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION (1983), GRADATION NO. CA18 WILL BE ACCEPTABLE. HOWEVER, IF IT IS ECONOMICALLY MORE SUITABLE TO USE GRADATION NO. CA6 QUALIFIED BY AN ADDITIONAL SPECIFICATION THAT THE COARSE AGGREGATE CONTAIN NO MORE THAN 5% PASSING NO. 200 SIEVE, THEN CA6 WILL BE ACCEPTABLE.

THEREFORE, USE IDOT CA18. ALTERNATE CA6 WITH $P_{200} \leq 5\%$

3. PLACEMENT

THE COARSE AGGREGATE BACKFILL SHOULD BE PLACED USING THE CLAMSHELL BUCKET USED TO EXCAVATE THE MUCK, SAND AND TILL. THE AGGREGATE CAN BE TRUCKED TO SLIP NO. 3, STOCKPILED A SUFFICIENT DISTANCE AWAY FROM THE BULKHEAD SO AS NOT TO

I.

SITE RESTORATION

A.

3. (CONTINUED)

AFFECT THE BULKHEAD STABILITY, PICKED UP BY THE CLAMSHELL AND THE CLAMSHELL LOWERED INTO THE WATER BEFORE OPENING TO MINIMIZE WATER TURBIDITY AND SPLASHING. THE COARSE AGGREGATE SHOULD BE PLACED IN HORIZONTAL LIFTS THE THICKNESS OF ONE CLAMSHELL BUCKET VOLUME. A LIFT SHOULD BE COMPLETE PRIOR TO A SUBSEQUENT LIFT AS MUCH AS POSSIBLE BY "BLIND" PLACEMENT. COMPACTION WILL NOT BE FEASIBLE NOR SPECIFIED. SOME COMPACTION OR REARRANGEMENT OF SOIL PARTICLES IS ANTICIPATED DURING SHEETPILE EXTRACTION. THE COARSE AGGREGATE BACKFILL WILL BE PLACED TO A LEVEL EQUAL TO THE TOP OF THE SAND OUTSIDE THE COFFERDAM.

B. Removal of Facilities & Decontamination

1. Action 1 - Cofferdam removal and decontamination

During the appropriate stage of construction a portion of the existing bulkhead wall, along the north side of slip No.3, within the limits of the proposed deep excavation shall be removed, decontaminated on site and disposed off site. After their relative construction life usefullness has been completed the temporary east end closure wall, temporary north side bulkhead wall and any temporary walers and struts shall be removed, decontaminated on site and salvaged.

SITE RESTORATION

I AREA A

B. REMOVAL OF FACILITIES & DECONTAMINATION

2 Dredging Equipment

All clam buckets, cables, crane shall be decontaminated after dredging activities are completed. See Appendix H for decontamination procedures.

3. Decontamination Facilities

After all items have been decontaminated, the decontamination facility is to be decontaminated and removed from the site

4 Fencing

Approximately 85' of fencing will be decontaminated and removed from the site.

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY LAB DATE 2-22-85 SUBJECT DESIGN REQUIREMENTS SHEET NO. I-85 OF
CHKD. BY TDC DATE 2-27-85 JOB NO. 11837

SITE RESTORATION

I. AREA A

C. FINAL GRADING/PAVING

At the completion of activities in this area, the area is to be restored to the original condition.

Paving for the truck loading & hopper pad is to be removed and disposed of in the parking lot containment cell, as well as paving for the decontamination station.

D Replacement of Structures

1. Replacement of Walkways and Finger Piers

To facilitate dredging operations and various other construction activities occurring in Slip No. 3 and the upper harbor; existing floating and fixed piers and related support piling, owned by Larsen Marine, shall be removed where they intefere with work. All items removed shall be decontaminated and temporarily stored on site within the construction limits. Immediately following work activities within the effected areas the floating and fixed walkways shall be reconstructed to match the existing conditions.

2 Reconstruct Permanent Bulkhead

To permit cofferdam installation at the west end of slip No. 3 and various related construction activities, a portion of the existing bulkhead wall along the north side shall be removed. At the appropriate stage of construction this bulkhead line shall be reconstructed at its present location utilizing new materials. Refer to design calculations located under Site Construction, item D, Action 1 - Cofferdam design.

SITE OPERATIONS/MAINTENANCE

WARZYN
ENGINEERING INC

Operations and Maintenance Provisions

I. Area A, Slip 3, Upper Waukegan Harbor

A. Transportation to Batch Plant

Dredging from Area A will be transported to the batch plant by trucks. The type of truck may depend on the consistency of the dredged materials. The preferred truck is a Redimix type. This truck would allow for minimum handling of the solids. The maximum truck size would be 10 yd^3 due to site access constraints. The trucks would be loaded adjacent to the cofferdam. The clamshell dredge would discharge the dredging into a hopper which would funnel the solids into the truck. The hopper would include splash curtains and drip trays to minimize spillage and contamination of the truck. The hopper would include vibrators to positively convey the dredging into the truck. The hopper would also include a screen basket to screen out large objects and debris from the truck. The screenings would be manually removed and properly disposed of in the parking lot containment area. The Redimix truck would not receive a full load of dredgings in order to allow for addition of the fixation agent. The trucks would then be routed through a decontamination station and a control station located near the Larsen Marine west gate. All documents, permits, manifests, etc. would be processed by the contractor prior to leaving the site. The trucks would proceed east on Sea Horse Drive and enter the lagoon site at the northeast corner. Flagmen would be required for traffic control at both locations.

The Redimix truck would proceed to the batch plant where a metered amount of fixation agent would be added directly into the Redimix truck vessel. The Redimix truck would then mix the fixation agent with the dredging prior to dumping the combined load into a curing cell. The truck would then proceed to the Lagoon area decontamination station and security control Station prior to returning to the cofferdam area to receive the next load. Should the use of Redimix type trucks prove to be undesirable or impractical; sealed, covered dump trucks would be utilized. Dump trucks conveying dredging with a high solids content (sand, etc.) would dump their load at the prefixation holding area. The solids would be moved to the batch plant with a bulldozer or front end loader and then conveyed up to the batch plant dredging hopper. The batch plant would meter the fixation agent and dredging, combining the two in the central mixer. The mixed solids would then be conveyed by dump truck to the curing cells.

Dump trucks conveying dredging with low solids content (muck, etc) would dump their load at a containment pit at the prefixation holding area. The dredging would be pumped from the containent pit up into the batch plant dredging hopper. The batch plant would meter the fixation agent and the dredging, combining the two in the central mixer. The mixed solids would then be conveyed by dump truck to the curing cells.

B. Pumping to Water Treatment Plant

1. Piping

The cofferdam is to have net inflow at all times. During clamshell dredging this inflow will be obtained by removal of the dredging volume from within the cofferdam. During times when the clamshell dredge is not operating, a portable pump will pump out of the cofferdam to Lagoon No. 1. This piping will be temporarily routed through Larsen Marine property or along the north sheet piling of Slip 3 and the upper harbor.

2. Pump

The pump will be a portable, self priming, gas driven type pump. The pump will have a capacity of 500 gpm. The pump will be operated as required to maintain net inflow to the cofferdam. This will be primarily when the clam shell dredge is not operating.

MABS/BL4

Operation and Maintenance Provisions

I. Area A, Slip 3, Upper Waukegan Harbor

C. Decontamination Procedure

All vehicles, equipment, and personnel that come into contact with PCB contaminated material will require decontamination prior to leaving the site. In general, the decontamination procedures for vehicles and equipment will consist of:

1. Water and detergent wash with scrubbing to remove all sediments from the equipment. Only as much water as necessary should be used, and care must be taken to keep splashing to a minimum.

2. Water rinse.

3. Collect washing and rinse fluids and dispose of properly by discharge back to the cofferdam or pumping to Lagoon 1.

This procedure should provide sufficient decontamination for equipment exiting the site. To ensure that sufficient cleanup has taken place, periodic wipe tests should be conducted using the following procedures:

1. Apply an appropriate solvent (hexane), to a piece of 11 cm filter paper (eg. Whatman 40 ashless, or Whatman "50" smear tabs or similar).

2. The moistened filter paper, held with a pair of stainless steel forceps, is used to thoroughly swab a 100 cm^2 area, measured using a sampling template.

3. The filter paper swab is then placed in a pre-cleaned glass jar and stored at 4°C for analysis for PCB's.

Quality assurance must be applied throughout the entire monitoring program. Blank swab samples and spiked samples will be needed to ensure the accuracy of the test results.

MABS/BM9

II AREA B, SLIP 3, UPPER WAUKEGAN HARBOR

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SITE PREPARATION

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MADISON, WISCONSIN

BY RAJ DATE 3-6-85 SUBJECT DESIGN ANALYSIS SHEET NO. II-1 OF
CHKD. BY DJO DATE 3-7-85 JOB NO. 11337
OMC/WAUKEGAN HARBOR

II AREA B

A. SEDIMENT DISPERSAL CONTROL DEVICE

Two parallel silt curtains spaced approximately 20 Ft. apart shall be located at the entrance to slip No. 3 immediately west of the present travel lift runway operated by Larsen Marine. The approximate length of silt curtain at this location is 120 ft. and the required height of silt curtain is approximately 18 ft. Both curtains will be continuous across the slip width and allowance for boat traffic is not provided for. The various elements comprising the silt curtain are as follows:

1. Anchor piles - Vertical pile provided for "tieing" the silt curtain to. Transmits the lateral force into the foundation soil.

2. Flotation device - Allows for the top of the silt curtain to maintain a constant relationship with the fluxuating harbor water elevation.

3. Chain - Provides structural integrity to the top of the silt curtain to allow for it to span between anchor piles.

4. Membrane - Vertical, synthetic curtain spanning between the anchors at harbor bottom and the flotation device. Partially controls current to reduce sediment transfer.

5. Anchorage - Continuous, flexible weight to maintain silt curtain bottom in contact with the harbor bottom.

Depending upon design loading condition assumed there are various combinations of materials and relationship of elements that may potentially be configured to achieve the most effective result in minimizing sediment transport.

B. Removal of Walkways and Finger Piers

To facilitate dredging operations and other activities occurring in the Slip 3 area, existing floating and fixed piers and related support piling, owned by Larsen Marine, shall be removed where they interfere with work. All items removed shall be decontaminated and temporarily stored on site within the construction limits.

2 sections of pier and 9 steel piles shall be removed

SITE CONSTRUCTION

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CHKD. BY [illegible] DATE 3/4/85 JOB NO. 11537

SITE CONSTRUCTION

II AREA B

A. HYDRAULIC DREDGING

Dredging depths in Area B do not exceed 5 feet, therefore it is possible a different dredge may be needed for Area C.

1. Dredge Type

The hydraulic dredge shall be a standard dredge with rotating head. The dredge will be discussed further in the Final Design Analysis. To prevent roiling, care should be exercised while dredging.

2. Rates & % Solids

The hydraulic dredge will operate at a rate of 3000 gal/min. Material to be dredged is at 40% solids and after dredging, it will be at a 10% - 15% solids condition.

3. Volume of Soft Sediment

The volume of soft sediment to be removed by hydraulic dredging is 978 cy. PCB concentrations range from 1000 to 10,000 ppm. For volume calculations, see Appendix D, Computer Analysis - Dredging Volumes.

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SITE CONSTRUCTION

I AREA B

A. HYDRAULIC DREDGING

4. Pipe Size and Route to Lagoon 1

The dredged material will be routed to Lagoon 1 via an 8" pipe. Approximately 1000 feet of pipe will be fixed, located in the lagoon area. The remainder will be floating or at the bottom of the harbor to accommodate boat ~~traffic~~. Distribution in the lagoon will be covered in section VII Lagoons

SITE RESTORATION

SITE RESTORATION

II AREA B

A. DECONTAMINATION & REMOVAL

All items leaving the site shall be decontaminated prior to transporting off site. These items are addressed below.

1. Dredge Equipment & Piping

Upon completion of dredging activities, the piping will be decontaminated, salvaged or disposed of in the containment cell. The dredge may continue to be used in Area C. If not, the hydraulic dredge shall also be decontaminated. Refer to Appendix H for decontamination procedures.

2. Sediment Dispersal Control Device Removal and Decontamination

After completion of dredging and related construction activities in slip No. 3 the sediment dispersal control device and related appurtenances shall be removed from the east end of slip No. 3, decontaminated, salvaged for reuse or removed from the site.

3. Piers / Piling

Upon completion of dredging activities, the piers and pilings removed for construction activities shall be replaced.

SITE OPERATIONS/MAINTENANCE

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BY LAB DATE 3-4-85 SUBJECT CMC SHEET NO. I-8 OF
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OPERATIONS/MAINTENANCE

A. PIPE ROUTING DURING OPERATIONS

The pipe to the Lagoon will be floating or located at the harbor bottom for boat access.

B. BOAT TRAFFIC

During dredging in slip 3, boat traffic will be completely suspended. The suspension will occur for approximately 4 months, spanning March to July of 1986.

C. DREDGING CONTROL

Soundings will be done to determine depths attained while dredging.

III AREA C, UPPER WAUKEGAN HARBOR

SITE PREPARATION

WARZYN

III Area C

A. SEDIMENT DISPERSAL CONTROL DEVICE

Two parallel silt curtains spaced approximately 50 ft. apart shall be located at the entrance to the upper harbor. The approximate length of each curtain is 220 ft. allowing for a 50 ft opening at the east end of the outermost curtain and a 50 ft. opening at the west end of the innermost curtain. The openings and distance between curtains will allow for small boats to traverse between the upper and lower harbors. The required height of silt curtain is approximately 26 ft. Refer to the design analysis portion for the silt curtain at the entrance to slip No.3 for additional information and description of major silt curtain elements.

B. Removal of Harbor Walkways & Finger Piers

To facilitate dredging operations and other activities occurring in the Upper Harbor existing floating and fixed piers and related support piling, owned by Larsen Marine, shall be removed where they intefere with work. All items removed shall be decontaminated and temporarily stored within the construction limits.

14 sections of pier and 55 steel piles shall be removed

SITE CONSTRUCTION

SITE CONSTRUCTION

III AREA C

A. HYDRAULIC DREDGING

Sediment having PCB concentrations ranging from 50 to 1,000 ppm will be hydraulically dredged. A depth of 25 feet (approximately) will be reached in some parts.

1. Dredge Type

Refer to AREA B for dredge type. A different dredge may be necessary for attainment of the 25 foot depth.

2. Rates & % Solids

Refer to AREA B for rates and percent solids.

3. Volume of Soft Sediment

The volume of soft sediment to be removed is 38,313 cy PCB concentrations range from 50 to 1,000 ppm. For volume generation, see Appendix D - Dredging Volumes.

4 Pipe Size & Route to Lagoon 2

The dredged material will be piped to Lagoon 2 via an 8" pipe. Approximately 250 feet of pipe will be fixed, located in the lagoon area. The remainder will be floating pipe or at the bottom of the harbor to accommodate boat traffic.

SITE RESTORATION

SITE RESTORATION

III AREA C

A DECONTAMINATION & REMOVAL

All items shall be decontaminated before removal from the contamination zone.

1. Dredge Equipment & Piping

After completion of the dredging activities, the hydraulic dredge, related accessories, and piping shall be decontaminated or disposed of in the containment cell. See Appendix H for decontamination procedures.

2. Sediment Dispersal Control Device Removal and Decontamination

After completion of dredging and related construction activities in the upper harbor the sediment dispersal control device and related appurtenances shall be removed from the south end of the harbor, decontaminated and removed from the site.

3. Piers / Pilings

After completion of dredging, the piers and pilings removed for construction activities shall be replaced.

SITE OPERATIONS/MAINTENANCE

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OPERATIONS/MAINTENANCE

A. PIPE ROUTING DURING OPERATION

The pipe to Lagoon 2 will be floating or at the bottom of the harbor to facilitate boat traffic. Dredging of the far side of the harbor could be done at night so that the floating pipe would minimally inhibit boat traffic

B. BOAT TRAFFIC

Traffic will be restricted to those crafts that are able to negotiate the sediment dispersion control device. This will occur for approximately 2 months spanning July to September, 1986

C. DREDGE CONTROL

Soundings will be performed to determine depths attained while dredging.

IV WATER TREATMENT PLANT(S)

1500 GPM
1500 GPM CONVERSION TO 200 GPM
200 GPM

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SITE PREPARATION

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SITE PREPARATION

SITE PREPARATION OF THE TREATMENT PLANT, LAGOONS, CURING CELLS AND BATCH PLANT HAS BEEN COMBINED, WHERE APPROPRIATE, IN THE FOLLOWING SECTION. WHEN ADDRESSED IN SUBSEQUENT PORTIONS OF THE DESIGN ANALYSIS, THIS SECTION WILL BE REFERENCED.

IV WATER TREATMENT PLANT(S)
1500 GPM AND 200GPM CONVERSION

A. REMOVAL OF EXISTING SITE FEATURES - DRAWING O26

DETERMINE GRADING AREA REQUIREMENTS FOR ENTIRE TREATMENT AREA.

AREA 1	=	230′ × 100′	=	23,000 FT^2
AREA 2	=	660′ × 950′	=	627,000 FT^2
AREA 3	=	850′ × 240′	=	204,000 FT^2
AREA 4	=	770′ × 360′	=	277,200 FT^2
AREA 5	=	380′ × 50′	=	19,000 FT^2
		TOTAL		1,150,200 FT^2 = 127,800 SQ YDS

GRUB AND CLEAR 127,800 SQ YDS

REFER TO APPENDIX F FOR IDENTIFICATION OF AREAS.

ASSUMPTIONS:

MANY CONCRETE FOUNDATIONS FROM PREVIOUS ACTIVITIES IN THIS AREA MAY STILL EXIST. THESE FOUNDATIONS WILL NOT BE REMOVED UNLESS NECESSARY FOR A SPECIFIC CONSTRUCTION ACTIVITIES. (IE PIPE INSTALLATION)

LOCATIONS OF THESE FOUNDATIONS HAVE NOT BEEN FIELD VERIFIED. LOCATIONS HAVE BEEN IDENTIFIED ON DRAWING O26, AND ARE BASED ON DRAWINGS PROVIDED BY OMC AND THE CITY OF WAUKEGAN.

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SITE PREPARATION

IV WATER TREATMENT PLANT(S)

IT SHOULD ALSO BE NOTED THAT NO CONTAMINATION STUDIES HAVE BEEN DONE IN THIS AREA. IT IS THEREFORE ASSUMED THAT THE AREA IS PRESENTLY UNCONTAMINATED AND SITE CONSTRUCTION WILL NOT REQUIRE DECONTAMINATION OF VEHICLES.

FEATURES TO BE REMOVED

450' OF FENCING

ALL VEHICLES AND CRIBS ON SITE

REMOVE AND RELOCATE

620' FENCING

3 TANKS (POSSIBLE FUEL STORAGE)

THE ENTIRE TREATMENT AREA MUST BE SAMPLED FOR PCB'S AND ADDITIONAL APPLICABLE PARAMETERS PRIOR TO ANY CONSTRUCTION ACTIVITIES. BOTH GROUNDWATER AND SOIL SAMPLES SHOULD BE ANALIZED.

THIS ACTION IS CRUCIAL TO VERIFY WHAT POTENTIAL CONTAMINATION TAKES PLACE AS A RESULT OF THE TREATMENT ACTIVITIES.

IF CONTAMINATION EXISTS AT LEVELS TO JUSTIFY FUTURE ACTION, THE PROPOSED CLEANUP ACTIVITIES COULD BE CONTINUED AND THIS AREA EVALUATED FOR ADDITIONAL WORK AT A LATER DATE.

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SITE PREPARATION

IV WATER TREATMENT PLANT(S)

B. SITE GRADING

1. PROOF ROLLING - ENTIRE AREA = 127,800 SQ YDS
   NECESSARY TO COMPACT AND STABILIZE THE EXISTING GROUND FOR ADDITIONAL FEATURE STABILITY

2. DRAINAGE - PERIMETER DRAINAGE SWALES MUST BE CONSTRUCTED TO CONTAIN AND/OR DIVERT FLOW AWAY FROM AND AROUND PROPOSED STRUCTURES. DUE TO THE SMALL AREA BEING DRAINED, THE DITCH SIZE WILL BE A NOMINAL 2:1 SIDE SLOPE, "V" SHAPED DITCH. 2700' OF DRAINAGE SWALE - REFER TO DRAWING 202
   DUE TO TOPOGRAPHY OF AREA - GRADING OF DITCHES WILL BE @ MINIMUM OR ZERO SLOPE AND WILL RELY ON HEAD DIFFERENTIAL AND GROUND INFILTRATION FOR RUN OFF CONTROL. DRAINAGE AREAS WILL BE A MINIMUM OF 10' WIDE.

3. EARTHWORK

   ASSUMPTIONS:
   DREDGE SPOILS ON SITE IS SUITABLE FOR AREA SUB-BASE

   MATERIAL WILL BE USED TO COVER EXISTING FOUNDATIONS AND CONSTRUCT BASE OF DIKES.

   STOCK PILES INCLUDE TWO AREAS - SNOW MOBILE TRACK BANK AND DREDGE STOCKPILE

   TRACK BANK 1390 CY

   SPOILS PILE 49750 CY

   TOTAL 51,140 CY

   REFER TO APPENDIX E FOR VOLUME CALCULATIONS

SITE PREPARATION

IV WATER TREATMENT PLANT(S)

C UTILITIES - ADDITIONAL & MODIFICATIONS

NO MODIFICATIONS OF EXISTING UTILITIES WILL BE REQUIRED FOR THE TREATMENT AREA.

1. Water

A WATER SERVICE WILL BE REQUIRED FOR SANITARY FACILITIES ETC @ THE TREATMENT PLANT OFFICES.

WATER SERVICE FROM EXISTING 24" MAIN = 600'

2. Electrical

3 PHASE ELECTRICAL SERVICE WILL BE REQUIRED TO THE TREATMENT PLANT AND OFFICES.

REQUIRE LENGTH OF SERVICE FROM EXISTING LOCATION = 1500'

3. Sanitary Sewers

A SINGLE SANITARY SEWER DISCHARGE WILL BE REQUIRED FROM THE TREATMENT PLANT TO DISCHARGE INTO THE HARBOR.

ALL SANITARY NEEDS FOR THE TREATMENT AREA WILL BE ROUTED THROUGH THE WATER TREATMENT PLANT. REFER TO THE TREATMENT PLANT CONSTRUCTION SECTION OF THE DESIGN ANALYSIS

4. TELEPHONE

TELEPHONE SERVICE WILL BE PROVIDED TO THE OFFICES @ THE TREATMENT PLANT

LENGTH FROM EXISTING SERVICE 600'

SITE PREPARATION

IV WATER TREATMENT PLANT(S)

D. FENCING & SECURITY

TWO MANNED SECURITY STATIONS WILL BE CONSTRUCTED FOR THIS AREA. ONE FOR THE TREATMENT PLANT AND ONE FOR BATCHING AREA. MUCH OF THE EXISTING FENCING CAN BE USED FOR SECURITY PURPOSES. ADDITIONAL REQUIRED FENCING LENGTH FOR TREATMENT AREA TOTAL 2460'

SECURITY STATIONS 2

E. OFFICES & PERSONNEL DECONTAMINATION

OFFICES AND PERSONNEL DECONTAMINATION WILL BE PROVIDED AS A PART OF THE TREATMENT PLANT IN THE OPERATIONS BUILDING. REFER TO THE TREATMENT PLANT CONSTRUCTION SECTION FOR DETAILS.

F. PARKING

EMPLOYEE PARKING WILL BE PROVIDED IN THE TREATMENT PLANT AREA. APPROXIMATELY 8000 SQ FT WILL BE AVAILABLE. THIS AREA WILL BE OUTSIDE THE CONTAMINATED ZONE. PERSONAL VEHICLES WILL NOT NEED TO BE PROCESSED THROUGH THE DECONTAMINATION STATION. CONSTRUCTION OF THESE AREAS IS OUTLINED IN THE SITE CONSTRUCTION SECTION.

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SITE PREPARATION

IV WATER TREATMENT PLANT(S)

G. STORAGE & RECEIVING (CONSTRUCTION STAGING AREA)

STAGING AREAS ARE PROVIDED IN THE TREATMENT PLANT AREA AND IN THE BATCHING AREA. DESIGN OF THESE AREAS ARE DISCUSSED IN THE SITE CONSTRUCTION SECTION OF THE TREATMENT PLANT AREA.

SITE CONSTRUCTION

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SITE CONSTRUCTION

IV WATER TREATMENT PLANTS

A. PAVING & ACCESS ROADS

PAVED AREA AROUND TREATMENT PLANT
10500 SQ YDS PAVING AND 1800' OF CURB
3 AREA DRAINS
560' SUBDRAIN PIPE TO THE PLANT PUMP STATION
PAVED AREA @ DISPOSAL STORAGE AREA
6200 SQ YDS PAVING AND 1560' OF CURB
2 AREA DRAINS
250' SUBDRAIN PIPE TO THE DECONTAMINATION STATION

GRAVEL ACCESS AREA @ TREATMENT PLANT
2990 SQ YDS

ACCESS TO THE TREATMENT AREA FROM OFF SITE WILL OCCUR OFF SEA HORSE DRIVE AT THE NORTH WEST CORNER OF THE TREATMENT AREA

DECONTAMINATION STATIONS

TWO DECONTAMINATION STATIONS WILL BE LOCATED IN THE TREATMENT AREA. ONE WILL SERVE MATERIAL TRANSPORT VEHICLES AND ONE WILL SERVE THE WATER TREATMENT PLANT.

THE BASE OF EACH STATION WILL CONSIST OF A CURBED - PAVED AREA WITH A SUMP PIT AND PUMP, ELECTRICAL SERVICE FOR THE PUMP AND A DISCHARGE PIPE TO THE WATER TREATMENT PLANT

@ TREATMENT PLANT

1000	SQ FT PAVING
140'	CURB
1	SUMP
1	PUMP
1	ELECTRICAL SERVICE
10'	PIPING

IV. Water Treatment Plants

Site Construction

B. Foundations

The water treatment facilities are expected to operate over a three year period (approximately March through November) and then be removed. To simplify construction and demolition, foundations will be above ground. Based on available information from previous investigations (reference Geotechnical Design Memorandum No. 1 dated February 21, 1985), a soil bearing pressure of 2KSF will be used until more definitive information is obtained. The final design will be based on additional geotechnical information to be obtained.

Construction activities are scheduled to cease for the winter. Combined with the effect of above grade construction, methods of foundation protection will be required. The suggested method to deal with this protection inexpensively is to use polyethylene sheeting over hay bales and straw.

MABS/BJ6

IV. Water Treatment Plants

Site Construction

C. Structures

Most concrete work associated with the water treatment plants is expected to be four inch slabs on grade with containment curbing. Location of slabs and curbs are as shown on the drawings. The curbs shall be a mountable type approximately six inches high.

Other structural considerations include railroad ties to support the carbon absorption units and the pressure filters.

The sedimentation basins are expected to be concrete tanks approximately 135 feet by 30 feet and 65 feet by 14 feet with a sidewall depth of 15 feet. Wall and base slab thickness is expected to be approximately 14 to 16 inches. Locations of tanks are as shown on the drawings.

The clearwells are expected to be modular metal tanks 60 feet and 25 feet in diameter with 10 feet sidewalls. The exterior fabric liner are expected to bear on existing soils. Locations of tanks are as shown on the drawings. The tanks are to be anchored down with metal posts embedded in concrete.

The mud well will be similar to the 25 feet diameter clearwell.

An operation building will be located near each of the water treatment plants. These buildings will be office trailers similar to those found on typical construction sites. This alternative was chosen because of the temporary nature of the project. No special foundations will be needed for these buildings.

Since these structures are to be used for a short time, design loads will be reduced accordingly with the exception of wind load.

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CONSULTING ENGINEERS PROJECT Waukegan Harbor BY T. Suszek

SHEBOYGAN, WISCONSIN PROJECT NO. 13935.005 PAGE NO. 1/12

Part 2 Design Requirements and Provisions
IV Water Treatment Plant(s)

Site Construction

D. Lagoon Effluent Pump Station

1. The Lagoon Effluent Pump Station required for the 1500 gpm and 200 gpm water treatment plants is an original design.

2. The submersible pump station will be designed in accordance with the following design criteria references:

a. Recommended Standards for Sewage Works - Great Lakes - Upper Mississippi River Board of State Sanitary Engineers.

b. Illinois Recommended Standards for Sewage Works - IEPA

c. Hydraulic Institute Standards for Centrifugal, Rotary & Reciprocating Pumps - Hydraulic Institute

d. Pumping Stations for Large Submersible Pumps - Flygt Corporation

3. Process flows and conditions

a. Maximum flow conditions occur during peak operation of the water treatment plant.

b. Assumptions:

1) 1500 gpm WTP operated continuously, 200 gpm WTP operated either continuously or as batch operation.

2) Finished grade elevation = 585

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CLIENT Warzyn DATE 2/28/95
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3.) Lagoon HWL = 597

4.) Lagoon LWL = 589

5.) Sedimentation Basin HWL = 599

6.) Invert elevation of influent piping to pump sta. = 585

4. Process Design

The minimum pump sump volume must be regarded as the minimum volume for satisfactory operation under the most unfavorable conditions, namely when the inflow to the sump is half the pump's output capacity. This case results in the maximum allowable number of starts per hour.

@ 1500 gpm, 10" Ø discharge pipe to sedimentation basin,

$V = 1.318\, C R^{0.63} S^{0.54}$ where $C = 100$
$R = D/4$, ft.

$\therefore V = 6.10$ fps
$V^2/2g = .579$ ft.
$S = 1.07$ ft/100 ft.

Estimated TDH =
a) static head = 599 - 589 = 10 ft.
b) h_L through static mixer = 2(2.92 psi) = 13.6 ft.
c) h_L through piping, valves, fittings = ~ 5 ft.
~ 29 ft.

Preliminary pump selection : 750 gpm @ 29 ft. TDH
Flygt 8" CS 3127, Imp. 442 OR EQUAL
hp = 10

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For 10 hp motor, 1750 rpm, maximum motor starts per hour is 5

Minimum Volume $= (Q \times 60\,min / \#\,starts/min)/4$

$= (1500\,gpm \times 60/5)/4 = 4500$ gallons

$= 4500\,gal / 1\,ft^3/7.4805 = 602\,ft^3$

If 6' I.D. RCP manhole is used for wetwell, minimum depth $= 602\,ft^3/(\pi(6)^2/4) = 21.3$ ft, (wetwell larger than 6'ø would be required). However, if the lagoon overflow structures and piping are sized correctly to allow continuous discharge of 1500 gpm from the lagoon (which must be the case to operate the 1500 gpm W.T.P. continuously) the W.L. in the wetwell will be approximatly equal to the W.L. in the lagoon overflow structure and only a minimum amout of storage volume would be required in the wetwell.

The critical minimum volume for the wetwell is when the 200 gpm WTP is operated during batch operation.

@ 200 gpm, 10"ø discharge pipe to sedimentation basin,

$V = 1.318\,C R^{0.63} S^{0.54}$ where $C = 100$

$R = D/4$, ft

$\therefore V = 0.81$ fps

$V^2/2g = .010$ ft

$S = .026$ ft/100 ft

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Estimated TDH =
a) static head = 599 - 585 = 14 ft
b) h_L through static mixers = 2(3.26psi) = 15 ft
c) h_L through valves, piping, fittings = ~5 ft
~34 ft

Preliminary Pump Selection: 200gpm @ 34 ft TDH
Flygt 4" CS 3102, Imp 436 OR EQUAL
hp = 5

For 5hp motor, 1700 rpm, max. motor starts = 5/hr

Minimum wetwell volume = (Q × 60min/#starts/min) / 4

= (200 × 60/5) / 4 = 600 gallons
= 600g / 1ft³/7.4805gal = 80.2 ft³

If 6' I.D. RCP manhole is used for wetwell, minimum depth = 80.2 ft³/(π(6)²/4) = 2.84 ft.

If pump on W.L. = 585
pump off W.L. = 582

To avoid necessity for explosion-proof pumps, provide enough wetwell volume to completely submerge pump during normal operation.

∴ 30 inches required to submerge pump

∴ bottom of pump wetwell = 582 - 2.5 = 579.5

Top of wetwell will be same elevation as top of lagoon to prevent surcharge.

Provide 6'Ø RCP as Lagoon Effluent Pump Station

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E. SEDIMENTATION BASIN

1. The sedimentation basins required for the 1500 gpm lagoon area water treatment plant and 250 gpm North Ditch area water treatment plant are original designs.

2. The sedimentation basins will be designed in accordance with the following design criteria references:

   a. Recommended Standards for Water Works - Great Lakes - Upper Mississippi River Board of State Sanitary Engineers.

   b. Title 35 Environmental Protection, Subtitle F Public Water Supplies, Chapter 2 Environmental Protection Agency, Parts 651-654, Technical Policy Statements, July 1, 1984 - IEPA

   c. Process Design Manual for Suspended Solids Removal - USEPA

3. Process flows and conditions

   a. Maximum flow conditions Lagoon area water treatment plant is 1500 gpm and maximum flow to North Ditch Area water treatment plant is 250 gpm.

   b. Assumptions:

      1) For lagoon area WTP, the same sedimentation basin used for 1500 gpm WTP will be used for 200 gpm WTP.

      2) Flow to 250 gpm North Ditch area WTP consists of maximum 200 gpm from dewatering equipment plus 50 gpm from waste backwash storage tank (mudwell).

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3) Surface Overflow Rate = 600 gpd/ft²

4) Detention Time = 4 hours

5) $L \approx 4w$

6) Freeboard = 18 inches

7) Weir Overflow Rate = less than 20,000 gpd/ft. of weir

8) Velocity through basin = less than 0.5 fpm

9) Basin will not be covered

10) Basin will not be provided with mechanical sludge collection equipment.

4. Process Design

For 1500 gpm WTP:

$(1500\,gpm \times 60\,min/hr \times 24\,hr/day) / w(4w) = 600\,gpd/ft^2/day$

$4w^2 = 3600$

$w = 30\,ft. \quad \therefore L = 120\,ft.$

$(30\,ft. \times 120\,ft. \times d) / (1500\,gpm / 7.4805\,gal/ft^3) = 4\,hrs. \times 60\,min./hr$

$d = 13.4\,ft.$

$\therefore$ w/ 18" freeboard, $d = 15\,ft.$

$(1500\,gpm \times 60\,min/hr \times 24\,hr/day) / 20{,}000\,gpd/ft.$ of weir

weir length = 108 ft.

= (6) - 10 ft. weir troughs, 5' ℄-℄

$(1500\,gpm / 7.48\,gal/ft^3) / (13.5 \times 30) = 0.495\,fpm$

$\therefore$ velocity through basin < 0.5 fpm

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For 250 gpm WTP

$(250\ gpm \times 60\ min/hr \times 24\ hr/day) / w(4w) = 600\ gpd/ft^2/day$

$4w^2 = 600$

$w = 12.25\ ft \quad \therefore L = 49.0\ ft.$

design basin $12' \times 50'$

$(12\ ft \times 50\ ft \times d) / (250\ gpm / 7.4805\ gal/ft^3) = 4\ hrs. \times 60\ min/hr$

$d = 13.4\ ft.$

$\therefore$ w/ 18" freeboard, $d = 15\ ft.$

$(250\ gpm \times 60\ min/hr \times 24\ hr/day) / 20{,}000\ gpd/ft\ weir$

minimum weir length $= 18\ ft.$

$(250\ gpm / 7.4805\ gal/ft^3) / 13.5 \times 12 = 0.21\ fpm$

$\therefore$ velocity through basin $\leq 0.5\ fpm$

F. CLEARWELL

1. The clearwells required for the 1500 gpm lagoon area water treatment plant and 250 gpm North Ditch area water treatment plant are original designs incorporating standard module components available from steel tank manufacturers.

2. The clearwells will be designed in accordance with the following design criteria references:

a. Recommended Standards for Water Works - Great Lakes - Upper Mississippi River Board of State Sanitary Engineers

b. Title 35 Environmental Protection, Subtitle F Public Water Supplies, Chapter 2 Environmental Protection Agency, Parts 651-654, Technical Policy Statements, July 1, 1984, — IEPA

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3. Process flows and conditions

a. Maximum flow conditions Lagoon area water treatment plant is 1500 gpm and maximum flow to North Ditch Area water treatment plant is 250 gpm.

b. Assumptions:

1.) For Lagoon area WTP, the same clearwell used for the 1500 gpm WTP will be used for 200 gpm WTP.

2.) Clearwell volume will be used for backwashing pressure sand filters.

3.) Minimum two hour detention time required.

4.) Clearwell will not be covered.

5.) Freeboard required is eighteen inches.

4. Process Design

For 1500 gpm WTP:

$(1500 \text{ gpm} \times 60 \text{ min/hr} \times 2 \text{ hr}) / 7.4805 \text{ gal/ft}^3 = 24,063 \text{ ft}^3$

For 60'Ø tank, I.D. = 58'-6"
Water depth = $24,063 \text{ ft}^3 / \pi (58.5)^2/4 = 8.95 \text{ ft}$

Provide 60'Ø x 12' high tank
Set gravity overflow @ elev. 10.5'
∴ volume from elev. 9' to 10.5' can be used for recycle pumping water level operating range

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For 250 gpm WTP:

a) minimum volume required
$= (250\,gpm \times 60\,min/hr \times 2\,hr)/7.4805\,gal/ft^3 = 4010\,ft^3$

b) volume required for backwash a pressure filter
w/ $250\,gpm/3\,gpm/ft^2 \Rightarrow 83.33\,ft^2$ filter area

minimum backwash requirements are 15 gpm/ft for 15 min.

$\therefore$ volume $= 83.33\,ft^2 \times 15\,gpm/ft^2 \times 15\,min = 18{,}750\,gal$
$18750\,gal/7.4805\,gal/ft^3 = 2507\,ft^3$

c.) volume required for 2 hr detention governs.

for 25'Ø tank, I.D. = 24'-8"
Water depth $= 4010\,ft^3/\pi(24.67)^2/4 = 8.4\,ft$

Provide 25'Ø x 10' high tank

G. MUDWELL

1. The mudwell (waste backwash tank) required for the 250 gpm North Ditch Area water treatment plant is an original design incorporating standard module components available from steel tank manufacturers.

2. The mudwell will be designed in accordance with the same design criteria references as the clearwells.

3. Process flows and conditions

a. Assumptions:

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1.) Maximum backwash flow = 18,750 gallons

2.) Waste backwash will be pumped to sedimentation basin

3.) Mudwell will not be covered.

4.) 18" freeboard required.

4. Process Design

For 250gpm WTP:

backwash volume = 18,750 gal. = 2507 ft^3

for 25'ø tank, I.D. = 24'-8"
depth required for one filter backwash
$= 2507\ ft^3 / \pi(24.67)^2/4 = 5.25\ ft.$

minimum height required for tank equals
1) height to keep pump submerged = 2 ft.
2) backwash storage = 5.25 ft
3) freeboard = 1.5 ft.
8.75 ft

Provide 25'ø x 10' high tank (same volume as clearwell).

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H. Equipment - Pumps, Valves, Feed Systems

1. The equipment required for the water treatment plants is standard equipment available from equipment manufacturers.

2. The equipment, pumping and feed systems will be designed in accordance with the following design criteria references:

a. Recommended Standards for Water Works - Great Lakes - Upper Mississippi River Board of State Sanitary Engineers

b. Title 35 Environmental Protection, Subtitle F Public Water Supplies, Chapter 2: Environmental Protection Agency, Parts 651-654, Technical Policy Statements, July 1, 1984 - IEPA

c. Pump Handbook - Karassik, Krutzsch, Fraser & Messina

d. Process Design Manual for Carbon Adsorption - USEPA

e. Waukegan Harbor Dredging & Dredge Spoil Treatment Parameters Developed from Bench Scale Laboratory Treatment Tests - Mason & Hanger Oct. 1980.

f. Kenics Technical Report BC-1 - Flocculation of Wastewater with the Static Mixer Unit - Kenics

g. Process Design Manual for Suspended Solids Removal - USEPA

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3. Process flows and conditions

a. Maximum flow conditions lagoon area water treatment plant is 1500gpm and maximum flow to North Ditch Area water treatment plant is 250gpm.

b. Assumptions:

1.) Chemical feed systems for liquid chemicals will be designed.

2.) Pressure sand filter feed rate will be 3gpm/ft^2.

3.) Carbon adsorption unit feed rate will be 3gpm/ft^2

4.) Minimum contact time required in carbon adsorption units is 15 minutes.

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4. Process Design

A. Chemical Feed Systems:

1. Polymer Feed Systems:

a. 1500 gpm WTP

@ 5 ppm dosage

$= 5 mg/l \times \frac{3.785 l}{gal} \times \frac{1 g}{1000 mg} \times \frac{1 lb}{453.59 g} \times \frac{1500 gal}{min} \times \frac{60 min}{hr} \times \frac{24 hr}{day} \times \frac{gal\ polymer}{9.09 lb\ polymer}$

= 9.92 gpd (90 lb./day)

= 0.41 gph w/ 24 HR/DAY OPERATION

@ 15 ppm dosage

= 9.92 gpd (3) = 29.75 gpd (270 lb./day)

= 0.41 gph (3) = 1.24 gph w/ 24 HR/DAY OPERATION

b. 200 gpm WTP

@ 5 ppm

$= 5 mg/l \times 3.785 \times 1/1000 \times 1/453.59 \times 200 \times 60 \times 24 \times 1/9.09$

= 1.32 gpd (12 lb./day)

@ 15 ppm

= 1.32 gpd (3) = 3.96 gpd (36 lb./day)

c. 250 gpm WTP

@ 5 ppm

$= 5 mg/l \times 3.785 \times 1/1000 \times 1/453.59 \times 250 \times 60 \times 24 \times 1/9.09$

= 1.65 gpd (15 lb./day)

2. Alum Feed Systems

a. 1500 gpm WTP

@ 15 ppm

$= 15 mg/l \times 3.785 \times 1/1000 \times 1/453.59 \times 1500 \times 60 \times 24 \times 1/5.4$

= 50 gpd

= 2.09 gph @ 24 HRS

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@ 45 ppm
= 50 gpd (3) = 150 gpd
= 2.09 gph (3) = 6.26 gph @ 24 HRS

b. 200 gpm WTP
@ 15 ppm
= 50 gpd × 200/1500 = 6.67 gpd
= 2.09 gph × 200/1500 = 0.28 gph

@ 45 ppm
= 6.67 gpd × 3 = 20 gpd
= 0.28 gph × 3 = 0.84 gph

c. 250 gpm WTP
@ 30 ppm
= 30 × 3.785 × 1/1000 × 1/453.59 × 250 × 60 × 24 × 1/5.4
= 16.69 gpd
= 0.70 gph

B. In-line static mixers will be used for coagulation and flocculation of the chemicals and wastewater prior to the sedimentation basin.

C. Sedimentation Basin Effluent Pumps

1. 1500 gpm WTP
a. 3 - 750 gpm (2 + 1 standby) submersible pumps will pump effluent from the sedimentation basin to the pressure sand filters.

b. Preliminary selection indicates a 750 gpm pump @ ~40 ft head w/ 15 hp motor will be required.

2. 200 gpm WTP
   a. 2-200 gpm (1+1 standby) submersible pumps will pump effluent from the sedimentation basin to the pressure sand filters.

   b. Preliminary selection indicates a 200 gpm pump @ ~40 ft. head w/ 5 hp motor will be required

3. 250 gpm WTP
   a. 2-250 gpm (1+1 standby) submersible pumps will pump effluent from the sedimentation basin to the pressure sand filters.

   b. Preliminary selection indicates a 250 gpm pump @ ~40 ft. head w/ 5 hp motor will be required

4. Final selection of the Sedimentation Basin Effluent Pumps will be made during final equipment and piping Design.

D. Pressure Sand Filters

1. 1500 gpm WTP

Filter Area Required = 1500 gpm / 3 gpm/ft² = 500 ft²
Provide (2) Horizontal Pressure Filters w/ 4 compartment ea.
Each compartment sized for 250 gpm @ 3 gpm/ft²
The required filters would be 10' ⌀ x 36' long w/ 6 compartments for filtering, 1 for backwashing, & 1 spare

@ backwash requirement of 15 gpm/ft² - backwash requirements are 1250 gpm/compartment

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2. 200 gpm WTP

When the 1500 gpm treatment plant is downsized to 200 gpm, (1) Horizontal pressure filter will be required of the two used during 1500 gpm operation.

3. 250 gpm WTP

Filter Area Required = 250 gpm/3 gpm/ft² = 83.3 ft²

Provide (1) Horizontal Pressure Filter w/ 3 compartments. Each compartment sized for 250 gpm @ 3 gpm/ft². The required filter would be 10'Ø x 36' long w/ 1 compartment for filtering, 1 for backwashing, & 1 spare

@ 15 gpm/ft² backwash flow, requirements are
15 gpm/ft² x 83.3 ft² = 1250 gpm/compartment

E. Carbon Adsorption Units

Standard pressure carbon adsorption units are available for lease. The units are 10'Ø x 8' straight side rated at 250 gpm each with 20 minutes of contact time. Each unit holds 20,000 pounds of activated carbon.

For the 1500 gpm treatment plant, 7 adsorption units will be required 6 + 1 spare.

For the 200 & 250 gpm treatment plants, 2 adsorption units each will be required 1 + 1 spare each.

The units come two to a skid and the skid can be set on railroad ties.

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F. Clearwell Pumps

1. 1500 gpm & 200 gpm WTP

a. During normal operation, water from the treatment plant will be discharged by gravity from the clearwell to the harbor.

b. During recycling of the plant effluent and during filter backwashing, the clearwell pumps will be required.

c. 3 - 650 gpm (2 + 1 standby) submersible pumps will pump water from the clearwell to be either recycled to the sedimentation basin or used for pressure filter backwashing.

d. Preliminary selection indicates a 650 gpm pump @ ~25 ft. head w/ 7.5 hp motor will be required.

2. 250 gpm WTP

a. During normal operation, water from the treatment plant will be discharged under pressure from the clearwell to a sanitary / storm sewer.

b. During recycling of the plant effluent and during filter backwashing, the clearwell pumps will also be used.

c. Sizing of the clearwell pumps is based on flow and pressure required for backwashing the sand filters.

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d. 3-650gpm (2+1 standby) submersible pumps will be required.

e. Preliminary selection indicates a 650gpm pump @ ~25ft head w/ 7.5 hp motor will be required.

3. Final selection of the Clearwell pumps will be made during final equipment and piping design.

G. Mudwell Pumps

1. Mudwell pumps will be required at the 250gpm North Ditch area water treatment plant to pump waste backwash water from the mud well to the sedimentation basin.

2. Size of the pumps is based on a pumping rate of 50gpm.

3. 2-50gpm pumps (1+1 standby) submersible pumps will be required.

4. Preliminary selection indicates a 50gpm pump @ ~20ft head w/ 2 hp motor will be required.

5. Final selection of the mudwell pumps will be made during final equipment and piping design.

IV. Water Treatment Plants

Site Construction

G.1 Utilities - Electrical (1,500 GPM WTP)

1. Electrical service to the site is available from Commonwealth Edison's existing power distribution system presently located approximately 700 feet north of the site on Sea Horse Drive.

2. A separately metered, 227/480 volt, three phase, four wire electric service will be located near the water treatment plant. This electric service will provide power for the security control station, decontamination station, lab, operation building, process motors and equipment, and area lighting.

3. The process and decontamination station areas will be illuminated to provide minimal general work area lighting. Other areas will be illuminated to provide minimal security lighting. The area will be illuminated using 150 watt HPS street lighting type luminaries with integral photo controls mounted on wood poles.

MABS/BK3

IV. Water Treatment Plants

Site Construction

G.2 Utilities - Electrical (1,500 gpm converted to 200 gpm WTP)

1. The electrical service provided for the 1,500 gpm water treatment plant will be modified to accommodate the changes in process motors and equipment for the 200 gpm conversion.

2. The area lighting provided for the 1,500 gpm plant will be adequate to serve the 200 gpm plant without modification.

MABS/BK4

IV. Water Treatment Plants

Site Construction

G.3 Utilities - Electric (200 gpm WTP North Ditch)

1. Electrical service to the site is available from Commonwealth Edison's existing power distribution system presently located approximately 200 feet south of the site near the south edge of the existing parking lot.

2. A separately metered, 120/240 volt, three phase, four wire electric service will be located near the water treatment plant. This electric service will provide power for the lab, operations building, process motors and equipment, decontamination station, security control station, and area lighting.

3. The process and decontamination station areas will be illuminated to provide minimal general work area lighting. Other areas will be illuminated to provide minimal security lighting. These areas will be illuminated using 150 watt HPS street lighting type luminaries with integral photo controls mounted on wood poles.

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IV. Water Treatment Plants

Site Construction

J. Water Quality Lab

Water quality must be monitored at several locations during the project period to prevent degradation of existing water quality. The approach to monitoring water quality during the project period is to monitor surface water before, during, and after dredging operations, monitor treatment plant discharges to the Waukegan Harbor, and to monitor groundwater, around the project site. Previous engineering studies, the Conceptual Design, and EPA studies, have addressed programs to monitor water quality for this project. The monitoring programs from those studies were incorporated into this design. Table 1 summarizes the sampling and testing program proposed for this project. The SSQMP provides additional guidance on the chemical data management program.

A water quality lab will be located near the 1500 gpm water treatment plant to monitor turbidity, PCB levels, and pH. Turbidity and pH will be analyzed on-site. The SSQMP discusses the turnaround time required for the analysis which will influence the contractors decision for on-site lab requirements (i.e., establish a fully equipped lab on-site or contract out the majority of the required testing.) The contractor's lab personnel will perform all sampling as well as testing requirements. The treatment plant operators will not perform any sampling or testing.

TABLE 1
SAMPLING AND TESTING PROGRAM

	Location	Frequency	Parameters
1.	Waukegan Harbor-Predredging (5 locations)	One time	Table 1 (SSQMP)
2.	Waukegan Harbor Dredging (6 locations)	Daily when dredging (7 weeks)	Table 1 (SSQMP)
3.	Upper Harbor Dredging (6 locations)	Daily when dredging (4 weeks)	Table 1 (SSQMP)
4.	Post Dredging-Water Samples (Same locations as in 2 and 3 - total of 12 samples	5 days total	Table 1 (SSQMP)
5.	Post Dredging Soil Samples (Locations in Figure 1 - SSQMP - 35 samples)	One Time	PCB and Total Solids
6.	Monitoring Wells (7 locations - as shown on plans)	Monthly for two years	Table 2 (SSQMP)
7.	Leachate Sump (1 location)	Weekly during dredging or monthly during storage in lagoon	PCB
8.	WWTP Effluent (2 plants) (2 samples)	Daily	PCB, pH, Turbidity

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Part 2 DESIGN REQUIREMENTS AND PROVISIONS
IV Water Treatment Plant(s)

Site Construction

K. Outfalls

1. The outfalls required for the 1500 gpm, 200 gpm, & 250 gpm water treatment plants are an original design.

2. The outfalls will be designed in accordance with the following design criteria references:

   a. Recommended Standards for Sewage Works - Great Lakes - Upper Mississippi River Board of State Sanitary Engineers.

   b. Illinois Recommended Standards for Sewage Works - IEPA

3. Process Flows and conditions

   a. Assumptions

      1. The plant effluent from the 1500 gpm & 200 gpm water treatment plants will flow by gravity to the harbor.

      2. The plant effluent from the 250 gpm North Ditch area water treatment plant will flow under pressure to a sanitary sewer or storm sewer.

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4. Process Design

The outfall from the clearwell at the lagoon area water treatment plant will consist of a 14 inch diameter gravity overflow pipe. The elevation of the overflow at the clearwell will be such that there will be two hours detention time in the clearwell prior to overflow. The 14 inch diameter outfall pipe will be routed above grade from the clearwell to the harbor. The pipe will be sloped sufficiently to allow unrestricted flow greater than 1500 gpm. Pipe supports will be provided as required.

The outfall from the 250 gpm North Ditch area water treatment plant will be a 6 inch diameter pressure line from the clearwell pumps. The pipe will discharge into a sanitary sewer until such time as the North Ditch Storm Sewer bypass is completed, and the outfall can be rerouted to the storm sewer.

IV. Water Treatment Plants

Site Construction

L. Decontamination Station

1. Decontamination stations will be located near the lagoon area water treatment plant and near the North Ditch area water treatment plant. Each station will be designed to handle all transport vehicle traffic as well as equipment and personnel. All traffic leaving the water treatment plant areas will be required to pass through the station prior to leaving the site. Each station will consist of a concrete pad overlain by a steel grating and enclosed by a small dike or curb. Grating is necessary in order to reduce contaminant transport via truck tires. The entire decontamination pad should be sloped into a single catch basin area where wash fluids can be collected or piped to the water treatment plant. A personnel decontamination station, with associated emergency equipment, will be located adjacent to the vehicle decontamination area.

2. The decontamination area will have security lighting. The contractor will have the option of providing additional lighting to accommodate work at night. The decontamination station will also require a source of pressurized clean water and electrical power.

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SITE RESTORATION

WARZYN ENGINEERING INC

IV. Water Treatment Plants

Site Restoration

A. Utility Removal

All utilities installed for this project will be removed, decontaminated and properly disposed of by the contractor.

B./ Structure/Equipment/Utility Removal and Decontamination

Following completion of the operation of the 1,500 gpm water treatment plant the equipment, (other than that which is to remain for the 250 gpm WTP), will be decontaminated and removed from the site. Equipment that is movable may be transported to the water treatment plant area decontamination station for cleaning. Quality assurance wipe tests will be conducted after cleaning and prior to removal. All cleaning fluids will need to be contained or directed to the operating water treatment plant for proper treatment and/or disposal.

Following completion of all major construction activities the two water treatment plants will be decontaminated and removed from the sites. Structures, equipment and utilities with no salvage value will be landfilled. Quality assurance wipe tests should be conducted after cleaning and prior to removal. All cleaning fluids will need to be collected for proper treatment and/or disposal by the contractor.

All equipment and structures associated with the decontamination station will be removed and properly disposed of by the contractor.

MABS/BMO

IV. Water Treatment Plants

Site Restoration

B.2 Structure Removal and Decontamination

Concrete removal will be simplified by keeping foundations and structures above grade. There will be no need to bury a foundation on site so any further use of this area will not be adversely affected. Decontamination and disposal of broken concrete shall follow the guidelines established for waste materials associated with this project.

Decontamination of steel tank walls, equipment, and construction trailers can be accomplished in the same manner as the decontamination of the vehicles involved in this project.

Refer to the decontamination procedure technical memorandum for a discussion on decontamination procedures.

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BY DJD DATE 2-19-85 SUBJECT OMC DESIGN ANALYSIS SHEET NO. 1 OF 2
CHKD. BY T.J.Lynch DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11837
WAUKEGAN, ILLINOIS

SITE RESTORATION

DETERMINE GRADING REQUIREMENTS FOR FINAL CLOSURE OF LAGOON/TREATMENT PLANT AREA.

IV WATER TREATMENT PLANT

C. FINAL GRADING

ASSUMPTIONS:

1. RESTORATION OF THE AREA WILL INCLUDE REMOVAL OF ALL MATERIALS AND EQUIPMENT BROUGHT ON SITE FOR THE PROJECT.
2. EXISTING ONSITE MATERIALS WILL REMAIN ON SITE AND WILL BE GRADED TO PROMOTE NATURAL SURFACE DRAINAGE.
3. NO TOP SOIL, SEEDING, FERTILIZING OR MULCHING WILL BE DONE BECAUSE THERE IS NO SUCH WORK DONE THERE @ THIS TIME
4. NO ADDITIONAL LANDSCAPING WILL BE DONE BECAUSE AGENCIES/OWNERS HAVE FUTURE PLANS FOR THIS AREA.

TOTAL AREA TO BE GRADED = 1,150,200 FT^2 (FROM PREVIOUS CALCULATIONS)

EXISTING ON SITE MATERIALS = 51,140 CY × 27 FT^3/CY = 1380780 FT^3

1380780 FT^3 / 1,150200 FT^2 = 1.2' DEEP OVER SITE, OR 2.4' @ CENTER & 0.0' @ PERIMETER.

REFER TO DRAWING C26 FOR COMPLETE AREA.

IV. WATER TREATMENT PLANT(S)

ADDITIONAL ITEMS TO BE REMOVED AND DECONTAMINATED INCLUDE THE FOLLOWING:

		TOTAL
PAVEMENT		16700 SQ YDS
CURBS		3360'
AREA DRAINS		4
DRAIN PIPING		810'
DECONTAMINATION FACILITY		
	PAVMENT	2000 SQ FT
	CURB	280'
	SUMPS	2
	PUMPS	2
	ELECTRICAL SERVICE	2
	RELATED PIPING	500
FENCING		2460'
SECURITY STATIONS		2
ELECTRICAL SERVICE (TMT PLANT)		1500'
WATER SERVICE		600'
TELEPHONE SERVICE		600'
ELECTRICAL SERVICE (BATCH PLANT)		600'

ADDITIONAL SITE RESTORATION OF THE TREATMENT AREA IS INCLUDED IN THE LAGOON - SITE RESTORATION SECTION.

SP 102931

SITE OPERATIONS/MAINTENANCE

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY DJD DATE 3-1-85 SUBJECT OMC - DESIGN ANALYSIS CONCEPT SUBMITTAL SHEET NO. 1 OF 1
CHKD. BY TJL DATE 3-7-85 JOB NO. 11837

OPERATION AND MAINTENANCE

IV. WATER TREATMENT PLANT(S)

A. INTAKE LOCATIONS

1. MANHOLES

ALL POTENTIALLY CONTAMINATED WATER BEING REMOVED FROM CONSTRUCTION RELATED ACTIVITIES WILL BE ROUTED TO THE TREATMENT PLANTS. DISCHARGE WILL OCCUR INTO A MANHOLE/WET WELL @ EACH TREATMENT PLANT.

WATER TO BE PROCESSED INCLUDES THE FOLLOWING:

1500 GPM TREATMENT PLANT

1. PUMPING FROM COFFER DAM
2. LAGOON UNDER DRAIN SYSTEM
3. LAGOON DECANT SYSTEM
4. DECONTAMINATION STATIONS
5. PAVED AREA SURFACE DRAINS

200 GPM TREATMENT PLANT - NORTH DITCH

1. DECONTAMINATION STATIONS
2. PAVED AREA SURFACE DRAINS
3. CONTAINMENT CELL DEWATERING SYSTEMS
   CRESCENT DITCH
   PARKING LOT
4. EXCAVATION DEWATERING
   CRESCENT DITCH/OVAL LAGOON
   NORTH DITCH (IF DEWATERED)

ADDITIONAL DISCUSSION OF THE DRAINAGE STRUCTURES IS INCLUDED IN THE SITE CONSTRUCTION SECTIONS FOR EACH AREA.

OPERATIONS AND MAINTENANCE PROVISIONS (PART 3)

IV. Water Treatment Plants

A. Intake Locations

2. Pumping And Rates

Water from Lagoon Areas 1 and 2 will flow by gravity from the lagoon outfall structures to the Lagoon effluent pump station where it will be collected. During the dredging activities, the supernatant from the lagoons will be continuously decanted and pumped to the water treatment plant at a rate of 1,500 gpm. After the completion of the dredging activities the pumping rate will be decreased to 200 gpm to handle the reduced flow of supernatant, rainwater and leachate which will occur during the duration of the lagoon dewatering process.

Water from the North Ditch Area dewatering activities will be pumped at a rate of 200 gpm to the North Ditch Area treatment plant for suspended solids and PCB removal.

3. Piping Size and Route

The discharge piping from the lagoon effluent pump station to the water treatment plant will be 10 inch diameter steel pipe. The discharge piping and valves at the pump station will be located above grade for accessibility but will then be routed below grade where it crosses the access road to the water treatment plant. After crossing the access road the pipe will be routed above grade to the sedimentation basin. The discharge piping from the dewatering equipment at the North Ditch Area will be 4 inch diameter and will be routed above grade from the dewatering activities to the treatment plant at the North Ditch site whenever possible. Where the pipe route crosses a transportation corridor it will be necessary to locate the pipe below grade.

B.1 Operation of 1,500 gpm WTP

The water treatment plant at the lagoon area will operate continuously during the dredging operation at a rate of 1,500 gpm for suspended solids and PCB removal from the lagoon supernatant. During non-dredging periods, when the water level in the lagoon drops to the sediment level and the flow of supernatant must be interrupted, treated water will be recycled through the treatment plant to maintain a continuous flow.

The lagoon effluent pumps will be controlled manually or by level controls in the sedimentation basin. Chemicals to aid in the coagulation and sedimentation of the lagoon supernatant will be added to the flow stream from the lagoon effluent pumps prior to the sedimentation basin. The polymer and alum chemical feed pumps will each be manually or automatically controlled. The chemical feed pumps will be interlocked with the lagoon effluent pump operation for automatic control.

The chemicals will be mixed with the wastewater through a motionless mixer(s). The sedimentation basin effluent pumps will be controlled manually or by level controls in the sedimentation basin.

A baffle and trough will be located upstream of the sedimentation basin effluent weirs. Should a layer of oil form on the surface of the sedimentation basin, the treatment plant operator will be able to manually skim the oil into the trough. The trough will discharge into 55 gallon drums for disposal of the oil.

The sedimentation basin effluent pumps will pump the effluent from the sedimentation basin to the pressure sand filters and subsequently to the carbon adsorption units, with the discharge from the carbon adsorption units going to the clearwell. If a sufficient level of treatment of the lagoon supernatant occurs in the treatment process, the water in the clearwell will overflow by gravity through the outfall to the harbor. If an acceptable level of treatment is not achieved, the water in the clearwell will have to be recycled by the clearwell pumps to the sedimentation basin where it will make another pass through the treatment process. The clearwell pumps will continue to recycle water from the clearwell to the sedimentation basin until an acceptable level of treatment is achieved to allow the effluent to be discharged to the harbor.

The clearwell pumps will be controlled manually or by level controls in the clear well.

During the course of operation of the treatment plant, fine suspended solids not removed by the sedimentation process will cause a pressure buildup in the sand filtration units and a deterioration of the effluent quality from the filters. Either turbidity measurements on the effluent of the sand filtration units or an excessive pressure buildup through the units can be used to determine backwash frequency of the units. When a sand filtration unit requires backwashing, the unit will be taken out of service and a spare sand filtration unit will be put into service to provide a continuous treatment of 1,500 gpm. Filtered water from the clearwell will be used for backwashing the sand filters with the clearwell pumps.

Throttling valves on the backwash influent lines to the sand filtration units and sight flow indicators on the effluent lines will allow the operator to control the backwash flow rate and the duration of the backwash. The backwash flow rate from the sand filtration unit can be directed by valving in the discharge line to either the sedimentation basin or Lagoon Area 2.

When dredging is complete and excess supernatant in the lagoons has been treated, the 1,500 gpm water treatment plant, exclusive of the equipment that will be used for the 200 gpm water treatment plant, will be removed.

B.2 Operation of 200 GPM WTP

The 200 gpm water treatment plant will be used to treat water resulting from rain, snow, supernatant, and leachate that accumulates during the period the contaminated solids are stored in the lagoons. During this period of time the 200 gpm treatment plant will be required to operate at both a batch and as a continuous operation. Coordination of the operation of the 200 gpm water treatment plant with the removal of solids from the lagoons should occur to avoid delays in the dewatering and removal process.

Operation of the 200 gpm treatment plant will be the same as for the 1,500 gpm treatment plant with one exception. During backwashing of a pressure sand filter, the backwash water shall be routed to the lagoons since the treatment plant will not be sized to handle the flow without equalization.

B.3 Operation of 250 GPM WTP

The North Ditch Area 250 gpm water treatment plant will be operated similar to the 1,500 gpm and 200 gpm treatment plants. Instead of controlling the operation of pumps in a pump station, the level controls in the sedimentation basin will control the operation of the dewatering equipment. Operation of the chemical feed systems, pressure sand filters and carbon adsorption equipment will be the same as for the 1,500 gpm and 200 gpm water treatment plant. If water pumped to the clearwell has been treated to an acceptable level it will be discharged to a sanitary sewer. If the level of treatment is not acceptable, the water will be re-cycled to the sedimentation basin and the dewatering operation will be discontinued until an acceptable level of treatment is achieved.

During backwash of a pressure sand filter the backwash flow will go to a mudwell for equalization. The mud-well pumps will pump the water to the sedimentation basin at a reduced rate. The mudwell pumps will be controlled the same as the lagoon effluent pumps for the 1,500 gpm and 200 gpm treatment plants.

The operation of the 250 gpm North Ditch area water treatment plant will be required during the entire construction period in the North Ditch area. Operation could either be continuous or intermittent.

C. Conversion to 200 GPM WTP

The lagoon effluent pump station, chemical feed system, sedimentation basin, free oil separation equipment, pressure filters equipment pad, carbon adsorption units equipment pad, clear well, and some of the pumps and piping used for the 1,500 gpm water treatment plant will also be used for the 200 gpm treatment plant. In addition, portions of the sand filtration equipment and carbon adsorption units which formed part of the 1,500 gpm water treatment plant may also be used.

The accumulated solids in the lagoon effluent pump station shall be cleaned out and the solids and water transferred to the lagoons. A high pressure water jet may be used to dislodge the accumulated sediment. The material can then be pumped back to the lagoons. After the pump station has been cleaned out and pumped dry, it shall be entered and inspected for leaks. If any leaks are found, the pump station shall be repaired and the location of the leaks noted so that soils adjacent to the leak location can be tested for PCB after the pump station is removed. After the pump station has been cleaned out, the three 750 gpm pumps shall be replaced with two 200 gpm pumps, required for operation of the smaller treatment plant.

The chemical feed system used for the 1,500 gpm treatment plant will also be used for the 200 gpm treatment plant. The feed rate for the polymer and alum metering pumps will have to be adjusted to compensate for the lower feed rates required for the 200 gpm treatment plant. The motionless mixers used to mix the chemicals with the wastewater will also have to be exchanged for smaller units during the downsizing of the treatment plant.

The sedimentation basin used for the 1,500 gpm treatment plant will also be used for the 200 gpm treatment plant. Accumulated solids in the sedimentation basin shall be cleaned out. This can be accomplished by opening the sedimentation drain valve and transferring the solids and water to the lagoon effluent pump station where they can be pumped back to the lagoons. The three 750 gpm sedimentation effluent pumps shall be replaced with two 200 gpm pumps, required for operation of the smaller treatment plant.

Portions of the sand filtration and carbon adsorption equipment used for the 1,500 gpm treatment plant shall be used for the 200 gpm treatment plant as required. The pressure filter and carbon adsorption equipment pads shall be cleaned following removal of the equipment and piping not required for operation of the 200 gpm treatment plant.

The clearwell used for the 1,500 gpm treatment plant shall also be used for the 200 gpm treatment plant. Cleanout of the clearwell shall consist of pumping the clearwell water to the harbor (assuming that it had previously been treated to an acceptable level). The clearwell drain valve shall then be opened and the tank rinsed of any accumulated sediment. The clearwell pumps used for the 1,500 gpm treatment plant will also be required for operation of the 200 gpm treatment plant.

D. Removal and Transport of Contaminated Media

At the completion of operation of the 200 gpm lagoon area treatment plant the tanks and equipment shall be drained to the lagoon effluent pump station where it will be pumped into tank trucks and hauled to the North Ditch Area treatment plant for treatment. The sand filter media and the carbon media shall be removed from the filters and carbon adsorption units and disposed of in a licensed landfill.

At the time of removal of the North Ditch Area treatment plant, the tanks shall be pumped dry into tank trucks and the water properly disposed of by the contractor. The filter media from the sand filters and the carbon in the carbon adsorption units shall be removed and hauled to a licensed landfill.

MABS/BH9

V BATCH PLANT

WARZYN
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SITE PREPARATION

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY CJD DATE 2-22-85 SUBJECT OMC - DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD. BY T.J. Lynn DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11837

SITE PREPARATION

V BATCH PLANT

SITE PREPARATION OF THE BATCH PLANT AREA IS DISCUSSED IN THE WATER TREATMENT PLANT SITE PREPARTION SECTION.

NO ADDITIONAL SITE PREPARATION WILL BE NECESSARY PRIOR TO SITE CONSTRUCTION.

THE ENTIRE FIXATION AREA WILL BE LINED WITH A CONTAINMENT DIKE AND LINER SYSTEM SIMILAR TO THAT USED FOR THE LAGOONS.

SITE CONSTRUCTION

WARZYN
ENGINEERING INC

SITE CONSTRUCTION

V BATCH PLANT

SITE CONSTRUCTION OF THE BATCH PLANT AREA, THE CURING CELLS, AND THE LAGOONS ARE SIMILAR AND HAVE BEEN COMBINED, WHERE APPROPRIATE IN THE LAGOON CONSTRUCTION SECTION. THE FOLLOWING SECTIONS ARE SPECIFIC TO THE BATCH PLANT AREA.

A. ACCESS

VEHICLE ACCESS INTO THE FIXATION AREA FROM OFF SITE WILL OCCUR OFF SEAHORSE DRIVE AT THE NORTH EAST CORNER OF THE SITE, THROUGH A GUARDED CONTROL POINT. ALL ROADS WILL HAVE A MAXIMUM SLOPE OF 10%

B. GRADING

THE ENTIRE BATCH PLANT AREA WILL BE WITHIN A DIKE. AND THE SUBGRADE WILL BE LINED. ONE SIDESLOPE OF THE DIKE WILL BE GRADED @ 5:1 (20%) FOR VEHICLE ACCESS, ALL OTHER DIKE SIDESLOPES (EXTERIOR) WILL BE 3:1 AND WILL BE SEEDED FERTILIZED AND MULCHED. ALL OTHER INTERIOR SLOPES WILL BE 3:1 AND WILL BE LINED, AS DISCUSSED IN THE LAGOON CONSTRUCTION SECTION.

V. Batch Plant

Site Construction

C. Foundations

Six column footings will be necessary to support the hoppers and mixer associated with the batch plant. Final design cannot be made until additional survey and soils information has been obtained. Preliminary sizing indicates there will be four column footings 11 feet-6 inches by 11 feet-6 inches by 2'-6 inches thick and two column footings 6 feet by 6 feet by 1 foot-6 inches thick.

D. Structures

A hopper to hold the fixing agent, a hopper to hold dredgings, and an intermediate mixer on columns are the structural elements associated with the batch plant. If prefabricated hoppers prove inadequate, structural design of the hoppers will include impact on their support. There is expected to be an eight inch slab on grade beneath and around the batch plant to prevent soil rutting and minimize access problems.

MABS/BJ9

V. Batch Plant

Site Construction

E. Hoppers

The batch plant receiving and discharge systems will be designed to permit flexibility in handling variations in material consistency, (solids vs liquid).

The batch plant will contain hoppers or bins for containing the fixation agent and the dredging. The fixation agent (cement, fly ash) will be pneumatically transferred to the storage bin. The dredging would be pumped or conveyed to the storage bin depending on material consistency.

F. Equipment

The batch plant will include a central mixer to mix the dredging with the fixation agent. The central mixer may be bypassed when using Redimix type trucks for material transport.

MABS/BL2

V. Batch Plant

Site Construction

H. Utilities - Electric

1. Electrical service to the site is available from Commonwealth Edison's existing power distribution system located east of the site along the west side of Sea Horse Drive.

2. A separately metered 277/480 volt, three phase, four wire electric service will be located near the batch plant. This electric service will provide power for the batch plant, dredged material sludge transfer pump, dredged material sludge mixer, fixed material sludge pump and area lighting.

3. A separately metered 120/240 volt, single phase, three wire electric service will be located near the security control station for power. This electric service will also provide power for the decontamination station steam generator and area lighting.

4. The decontamination station area will be illuminated to provide minimal general work area lighting. The security station will be illuminated to provide minimal security lighting. These areas will be illuminated using 150 watt HPS street lighting type luminaries with integral photo cells mounted on wood poles.

MABS/BK7

I-6

V. Batch Plant

<u>Site Construction</u>

I. Fixation Media

Refer to the Technical Memorandum entitled "Fixation of Dredging Material from Waukegan Harbor," dated February 22, 1985, for a discussion on the fixation process (included in the Appendix).

MABS/BO2

V. Batch Plant

Site Construction

J. Transportation Off-Site Routing

Material removed from the curing cells will be considered hazardous, and will be disposed of off-site at a licensed chemical landfill. The fixed material, of a non-flowable consistency, will be loaded into lined transport trucks at the off-site disposal staging area. All transport trucks will require decontamination at the lagoon area decontamination station prior to exiting the site. Appropriate hazardous waste manifests and placarding must accompany the wastes off-site.

After leaving the site it will be the contractors responsibility to comply with local truck routes. The contractor must be licensed in the State of Illinois, and all other states which may be appropriate, in order to transport the material to a licensed landfill. the contractor must also comply with all applicable EPA and DOT regulations. Reasonable steps must be taken by the contractor to ensure that no release of hazardous materials occurres during shipment, and must have an emergency spill response plan in the event of any accidental release.

MABS/BK8

SITE RESTORATION

V. Batch Plant

Site Restoration

A. Utility Removal

All utilities installed for this project will be removed, decontaminated and properly disposed of by the contractor.

C./ Structure/Equipment Removal and Decontamination

Following completion of the sediment fixation process, the batch plant and associated equipment will be decontaminated and removed from the site. Equipment and accessories that are moveable may be transported to the lagoon area decontamination station for cleaning. However, the batch plant itself will need to be decontaminated in place prior to removal. Quality assurance wipe tests should be conducted after cleaning and prior to removal. All cleaning fluids will need to be contained or directed to the water treatment plant for proper treatment and/or disposal by the contractor.

MABS/BM1

SITE RESTORATION

V BATCH PLANT

SITE RESTORATION OF THE BATCH PLANT AREA WILL OCCUR FOLLOWING REMOVAL OF ALL "FIXED" MATERIAL TO THE APPROPRIATE DISPOSAL AREAS.

B. FINAL GRADING

1. Volumes

CLOSURE OF THE BATCHING AREA WILL REQUIRE THE REMOVAL OF 1390 CY OF SOILCEMENT AND 2775 CY OF CLAY LINER, ALL OF WHICH IS CONSIDERED TO BE CONTAMINATED AND MUST BE DEPOSITED IN THE PARKING LOT CONTAINMENT CELL.

REFER TO THE LAGOON CONSTRUCTION SECTION FOR A COMPLETE DESCRIPTION OF VOLUME CALCULATIONS AND DRAINAGE.

APPROXIMATELY 2775 CY OF A GRANULAR UNDERDRAIN LAYER AND 2775 CY OF THE SECONDARY CLAY LINER MUST BE REMOVED FROM THE SITE.

REMOVAL OF ADDITIONAL MATERIALS AND FINAL GRADING OF THIS AREA IS DISCUSSED IN THE SITE RESTORATION SECTION OF THE LAGOONS.

V. Batch Plant

Site Restoration

C.2 Structural Removal and Decontamination

Concrete removal will be simplified by keeping foundations and structures above grade. There will be no need to bury a foundation on site so any further use of this area will not be adversely affected. Decontamination and disposal of broken concrete shall follow the guidelines established for waste materials associated with this project.

Decontamination of steel tank walls, equipment, and construction trailers can be accomplished in the same manner as the decontamination of the vehicles involved in this project.

Refer to the decontamination procedure technical memorandum for a discussion on decontamination procedures.

MABS/BKO

SITE OPERATIONS/MAINTENANCE

Operation and Maintenance Provisions

V. Batch Plant

A. Mixing Rates

It is apparent that the contractor will have to make field adjustments to the fixing process to suit the potential non-uniform material characteristics. The technical memorandum entitled "Fixation of Dredging Material from Waukegan Harbor," dated February 22, 1985, addresses flexibility and constraints of the fixing process.

B. Transport to Curing Cells

The batch plant must be designed to permit flexibility in handling materials of various solids content (solid vs. liquid).

Dredging transported to the batch plant in Redimix trucks would remain in the Redimix truck. The fixation agent would be metered in the batch plant and added directly to the truck. The truck would then mix the material and dump directly to the curing cell(s).

Dredging transported to the batch plant in dump trucks would be conveyed (bucket elevator) or pumped to the batch plant dredging hopper. The dredging and fixation agent would be metered and then mixed in the batch plant central mixer.

The mixed solids would be discharged to a dump truck and conveyed to the curing cell(s).

C. Operations

The batch plant operation must be carefully monitored and controlled. Variations in the moisture content of each load of dredging must be monitored and the amount of fixation agent adjusted accordingly. Too much fixation agent will result in material handling problems. Too little fixation agent will result in free water remaining in the dredging. Close control of the batch plant operation is required to minimize these potential problems.

MABS/BL5

VI CURING CELLS

SITE PREPARATION

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

BY DJD DATE 3-1-85 SUBJECT OMC - DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD. BY TJLuna DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11B33

SITE PREPARATION

VI CURING CELLS

SITE PREPARATION OF THE CURING CELL AREA IS INCLUDED IN THE SITE PREPARATION SECTION FOR THE WATER TREATMENT PLANT.

ACTIONS WILL INCLUDE THE FOLLOWING:

A. REMOVAL OF EXISTING FEATURES
B. SITE GRADING
C. UTILITIES
D. FENCING

SITE CONSTRUCTION

WARZYN ENGINEERING INC

SITE CONSTRUCTION

VI CURING CELLS

SITE CONSTRUCTION OF THE CURING CELL AREA, THE BATCH PLANT AND LAGOONS IS SIMILAR AND HAVE BEEN COMBINED, WHERE APPROPRIATE, IN THE LAGOON CONSTRUCTION SECTION.

ITEMS SPECIFIC TO THE CURING CELLS ARE DISCUSSED AS FOLLOWS:

STORAGE VOLUME

BASED ON AN AVERAGE DEPTH OF 4' OF MATERIAL IN THE CURING CELLS, TOTAL STORAGE IS APPROXIMATELY 7500 CY. (REFER TO VOLUME/AREA CALCULATIONS IN APPENDIX F)

APPROXIMATELY 1 FOOT OF FREEBOARD REMAINS ON THE DIKE SIDE SLOPE. SINCE THE "FIXED" MATERIAL WILL BE IN A NON FLOWABLE CONDITION, AND PLACEMENT CAN BE CONTROLLED, 1 FOOT IS ADEQUATE FOR THE DIKE FREEBOARD.

ACCESS

VEHICLE ACCESS TO THE CURING CELL AREA FROM OFF SITE WILL OCCUR OFF SEA HORSE DRIVE, AT THE NORTH EAST CORNER OF THE TREATMENT AREA. TRAFFIC WILL BE CONTROLLED AT THE GUARD HOUSE. ALL VEHICLES AND EQUIPMENT LEAVING THIS AREA MUST BE DECONTAMINATED

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SITE CONSTRUCTION

VI CURING CELLS

GRADING

THE CURING CELLS WILL BE CONSTRUCTED WITH LINED DIKES AND A LINED BASE. ONE INTERIOR SIDE SLOPE OF THE DIKE WILL BE GRADED @ 5:1 (20%) FOR VEHICLE ACCESS WHEN PLACING AND/OR REMOVING FIXED MATERIAL. ALL OTHER SIDE SLOPES WILL BE CONSTRUCTED @ 3:1 (33%). EXTERIOR SIDE SLOPES WILL BE SEEDED, FERTLIZED AND MULCHED.

DIKE STABILITY

THE LAGOON DIKES ARE THE LARGEST IN THE TREATMENT AREA AND WILL BE ANALYZED FOR STABILITY IN THE LAGOON SITE CONSTRUCTION SECTION.

ADDITIONAL SITE CONSTRUCTION ACTIVITIES ARE DISCUSSED IN THE LAGOON SITE CONSTRUCTION SECTION.

ACTION No. 1 - CONCRETE DIVIDER WALL DESIGN

1. The concrete divider wall design is an original design.

2. Design criteria references

a. Reinforced Concrete Design - Wang & Salmon

b. Building Code Requirements for Reinforced Concrete - ACI 318-83

c. Foundation Analysis and Design - Bowles

d. Concrete Structural Design for Buildings - TM 5-809-2 AFM 88-3, Chap 2

e. Navfac DM7

3. Structural design loads and conditions

a. Loading Condition No. 1 - Lateral pressure on one side of wall due to submerged solids. Occurs during filling operation.

b. Loading Condition No. 2 - Lateral pressure on one side of wall due to hydrated solids and equipment impact during removal of solids.

c. Assumptions:

1) Wall height = 5'

2) Depth of solids = 4'

3) No uplift

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d. Backfill parameters - Refer to R.H. Weber discussion following the end of this section for development of the material parameters.

Equivalent Fluid Pressure = 100 PCF (Includes water)
K_o = 1.0 ; At rest pressure coefficient
} During filling

γ_{solids} = 90 PCF
K_o = 0.5
Equivalent Fluid Pressure = 45 PCF
} After hydration

e. Seismic design considerations are not applicable for this design because of the location being one of low intensity and frequency and the temporary nature of the structure.

4. Minimum concrete compressive strength @ 28 days: 3000 PSI.

Reinforcing steel: ASTM A-615 Grade 60.

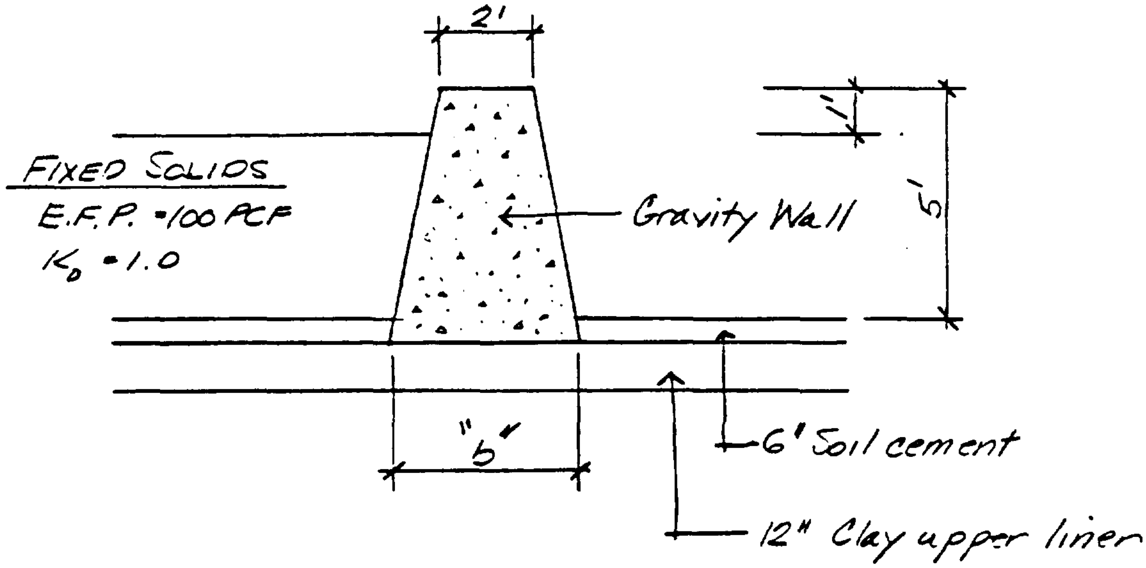
5. Description of the Structural System -

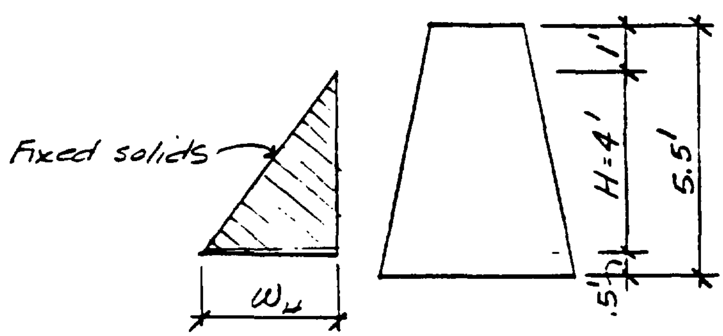
The concrete divider wall is a reinforced concrete structure separating the curing cell into three compartments. The wall shall be designed as a gravity structure for stability against overturning and sliding. The walls will be battered to increase the base width.

6. There are no miscellaneous design features

7. There is no site adaptation of a standard or existing design.

8. STRUCTURAL COMPUTATIONS -





LATERAL PRESSURE DIAGRAM

$\omega_H = K_0 \times EFP \times H = 1.0 \times 100 \times 4 = 400$ #/FT/FT

M_0 = Overturning moment = $\omega \times H \times 1/2 \times [H \times 1/3 + .5]$

$= 400 \times 4 \times 1/2 [4 \times 1/3 + .5] = 1467$ '-#/FT

BY KAV DATE 3-4-85 SUBJECT ACTION 1 - CONCRETE DIVIDER WALLS OMC / WAUKEGAN HARBOR SHEET NO. 4 OF 7
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Magnitude of resisting moment shall be such that location of resultant falls within the kern (middle 1/3^RD) of the base width. This will assure positive pressure for the entire wall width. For the most economical design the resultant shall fall within the outer 1% of the kern.

$$\therefore b - \left[\frac{M_r - M_o}{W}\right] = \frac{2b}{3} \; ; \; \frac{M_r - M_o}{W} = \frac{b}{3}$$

$$M_r = W \times b \times 1/2 \quad \therefore W \times b/2 - M_o = \frac{bW}{3}$$

$$\therefore M_o = \frac{1}{6} bW \; ; \; W = \frac{2+b}{2} \times 5.5 \times 150 = 825 + 412.5b$$

$$1467 = \frac{1}{6} b \times (825 + 412.5b) \; ; \; 1467 = 137.5b + 68.75b^2$$

$$\therefore b^2 + 2b - 21.34 = 0 \; ; \; b = \frac{-2 + \sqrt{2^2 + 4 \times 21.34}}{2} = 3.73'$$

$$\therefore M_r = \frac{2 + 3.73}{2} \times 5.5 \times 150 \times \frac{3.73}{2} = 4405\ '\#/FT$$

$$S.F. = \frac{M_r}{M_o} = \frac{4405}{1467} = 3.0 \quad \therefore OK$$

Toe Pressure - $f_{brg} = \frac{2W}{b} = \frac{2 \times (825 + 412.5 \times 3.73)}{3.73} = 1267\ PSF < 5000 \therefore OK$

Sliding -

Determine whether keying into the soil cement is adequate to resist sliding

$$P_H = \omega_H \times H \times 1/2 = 400 \times 4 \times 1/2 = 800\ \#/FT$$

$$\therefore P_u = 1.7 P_H = 1.7 \times 800 = 1360\ \#/FT$$

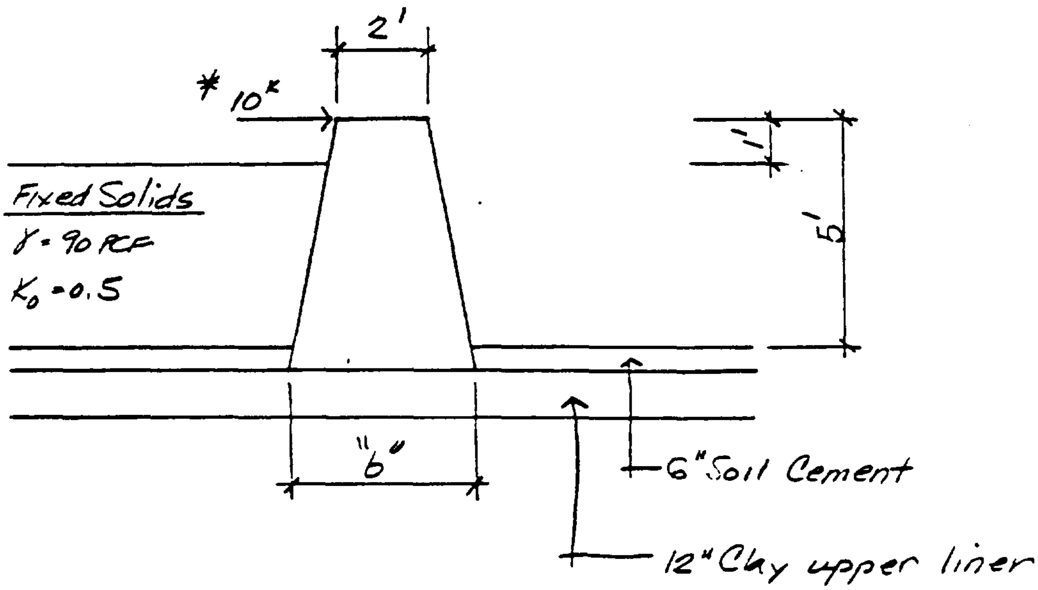
$P_{ALLOW} = \phi(.85) f'_c A$

$= 0.70 \times .85 \times f'_c \times 6 \times 12 = 42.84 f'_c$

$P_u / P_{allow} = 1.0 \quad \therefore \quad 1360 = 42.84 f'_c$

$\therefore f'_{c\,req'd} = 31.8$ psi <u>OK</u> Soil cement compressive strength is generally in the range of 300-800 psi. Therefore, taking into account that frictional resistance was not considered the cross section for the gravity wall is controlled by the overturning requirements.

LOADING CONDITION NO. 2



* Because of the continuity and stiffness of the wall assume that the 10k lateral impact load is distributed over ½ the length of the structure in the evaluation of stability.

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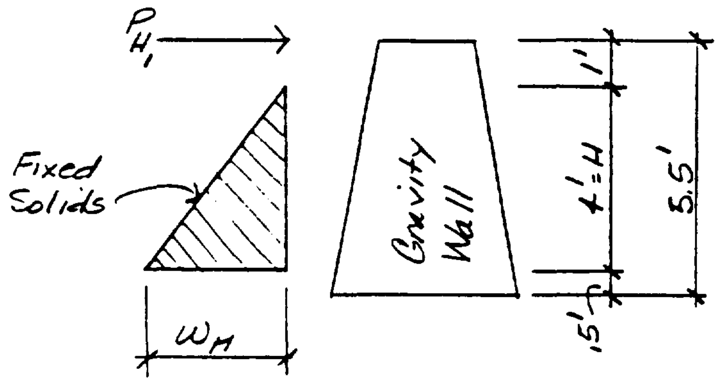


LATERAL PRESSURE DIAGRAM

$\omega_H = K_o \gamma H = 0.5 \times 90 \times 4 = 180 \text{ \#/FT/FT}$

$P_{H_1} = 10 \times 10^3 / 80 = 125 \text{ \#/FT}$

$M_o = \omega_H \times H \times 1/2 \,(H \times 1/3 + .5) + P_{H_1}(1 + H + .5)$

$= 180 \times 4 \times 1/2 \,(4 \times 1/3 + .5) + 125(5.5)$

$= 1348 \text{ '-\#/FT} < \underbrace{1467 \text{ '-\#/FT}}_{\text{pg. 3}}$ ∴ Does not control overturning stability

By inspection sliding does not control.

Reinforcing requirements

By inspection because end fixity or support does not exist it does not appear that lateral bending moments will develop. However, assume that the 10^k concentrated load would have to be distributed over an 80' length.

$\therefore M_{max} = \frac{PL}{8} = \frac{10 \times 80}{8} = 100^{\text{'-k}}$ $M_u = 1.7 M_{max} = 1.7 \times 100 = 170^{\text{'-k}}$

$R_u = M_u / \phi b d^2$; $b = 66''$, $d_{min} = 21''$

$\therefore R_u = \dfrac{170 \times 12 \times 10^3}{0.9 \times 66 \times 21^2} = 77.9$ $\quad \rho = \dfrac{1}{m}\left(1 - \sqrt{1 - \dfrac{2 \times m \times R_u}{f_y}}\right)$

$m = f_y / .85 f_c' = 60 \times 10^3 / .85 \times 3 \times 10^3 = 23.53$

$\rho = \dfrac{1}{23.53}\left(1 - \sqrt{1 - \dfrac{2 \times 23.53 \times 77.9}{60000}}\right) = 0.00132 < \rho_{min}$

$\therefore A_{s_{reqd}} = 4/3\,\rho b d = 4/3 \times 66 \times 21 \times .00132$ ACI 10.5.2

$= 2.44^{\square''}$

Temperature and Shrinkage

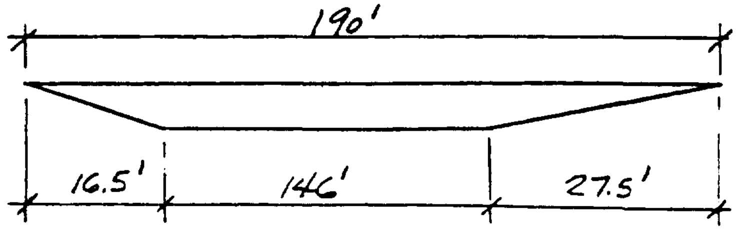
$A_{s\,HOR} = 0.002 \times 66 \times \left[\dfrac{24 + 45}{2}\right] = 4.55^{\square''}$ evenly distributed to ea. face. ACI 14.3.3

$A_{s\,vert} = 0.0012 \times 12 \times \left[\dfrac{24 + 45}{2}\right] = 0.5^{\square''}/FT$ evenly distributed to ea. face ACI 14.3.2

CONCRETE DIVIDER WALL CRITERIA

Wall height = 5'-6"
Top width = 2'-0"
Base width = 3'-9"
Hor. reinf = 8-#5 @ 8½" % Ea. face
Vert. reinf = #4 @ 9½" % Ea. face

Volume :



Avg. Length = 146 + (27.5 + 16.5)½ = 168 LF

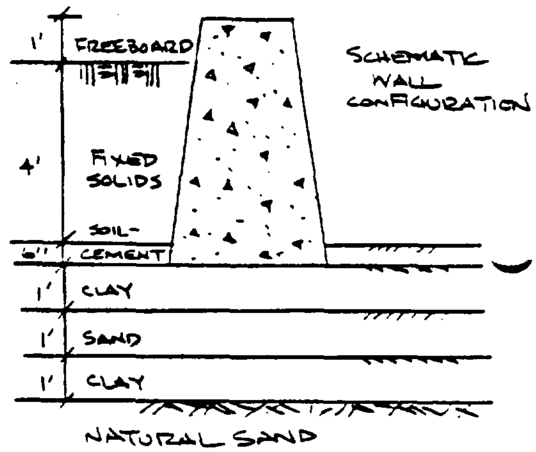
$\therefore$ Volume $= (2 + 3.75) \times ½ \times 5.5 \times 168 \times 2 \times 1/27 = 197$ Say 200 CY

LATERAL PRESSURE FOR DESIGN OF CURING CELL CONCRETE DIVIDER WALLS

ACCORDING TO CH2M HILL CONCEPT REPORT, p. 2-10, CURING CELL WILL BE DIVIDED INTO 3 COMPARTMENTS BY A 2-FT THICK, 5-FT HIGH CONCRETE WALL, AND p. 2-10, CURING CELL WILL BE LINED WITH 1 FT CLAY, 1 FT SAND, 1 FT CLAY AND 6" SOIL-CEMENT.

ACCORDING TO T. LYNCH'S PRELIMINARY CONSTRUCTION SCHEDULE, CURING CELLS WOULD BE USED ONLY FOR ONE SUMMER AND REMOVED PRIOR TO WINTER. THEREFORE, ASSUME FROST FOOTINGS NOT NECESSARY. SINCE FROST FOOTINGS NOT NECESSARY, ASSUME FOOTINGS WILL BE ESTABLISHED 6 IN. BELOW TOP OF LINER AND BE SUPPORTED ON THE UPPER CLAY LINER. COMPACTED CLAY SHOULD HAVE ALLOWABLE BEARING CAPACITY OF AT LEAST 5000 PSF IF CONSIDER IT WILL BE UNDERLAIN BY COMPACTED SAND, CLAY AND NATURAL SAND. VERTICAL LOAD WILL BE MINIMAL. THEREFORE, FOOTING WIDTH WILL NOT BE CONTROLLED BY VERTICAL LOAD BUT PROBABLY BY LATERAL LOAD. SOIL-CEMENT WILL BE COMPACTED AGAINST WALL TO FORM A TIGHT SEAL ALONG SOIL-CEMENT/WALL FACE. UPLIFT ALONG BASE OF WALL IS ANTICIPATED TO BE NEGLIGIBLE FOR SHORT-TERM CONDITION DUE TO RELATIVE IMPERMEABILITY OF SOIL-CEMENT AND TIGHT SEAL WITH CLAY AT WALL BASE.

WORST CASE FOR LATERAL PRESSURE MAY OCCUR WHEN ONE CELL IS FULL AND ADJACENT CELL IS EMPTY. SOLIDS WILL BE FIXED BY ADDING PORTLAND CEMENT OR OTHER FIXING AGENT. SOLIDS AFTER FIXING IN BATCH PLANT ARE ASSUMED TO STILL BE FLOWABLE. AFTER HYDRATION OCCURS, SOLIDS ARE ASSUMED TO BE NON-FLOWABLE SUCH THAT THEY CAN BE REMOVED BY END LOADER.



FLOWABLE CONDITION

IF SOLIDS WILL CONTAIN FREE WATER SUCH THAT THEY CAN BE CONSIDERED SUBMERGED:

EQUIVALENT FLUID PRESSURE $\gamma_{equiv} = K(\gamma_{solids} - \gamma_{water}) + \gamma_{water}$

SINCE WALLS OF CURING CELL WILL BE RELATIVELY THICK FOR SMALL LOADING, ASSUME AT-REST LATERAL EARTH PRESSURES (K_o) WILL APPLY.

$$K_o = 1 - \sin\phi$$

FIXED SOLIDS COULD RANGE FROM MUCK TO SAND TO CLAY TILL. ASSUME MUCK AND CLAY WILL BE SATURATED COHESIVE SOIL SUCH THAT $\phi = 0°$. ASSUME SAND IS LOOSE SUCH THAT $\phi = 30°$.

MUCK AND CLAY : $K_o = 1 - \sin 0° = 1.0$ ← WORST CASE ✓

SAND : $K_o = 1 - \sin 30° = 0.5$

ASSUME FIXED SOLIDS WILL BE EITHER END DUMPED FROM TRUCKS INTO CURING CELL OR DROPPED FROM CONVEYOR. IF PUMPED, DENSITY SHOULD BE SIMILAR. FROM J.E. BOWLES, <u>FOUNDATION ANALYSIS AND DESIGN</u>, p. 86, TABLE 3-4, ASSUME MATERIAL WILL HAVE THE CONSISTENCY OF VERY SOFT CLAY → USE $\gamma_{sat} = 100$ PCF ✓

$$\gamma_{equiv} = 1.0\,(100 - 62) + 62 = \underline{\underline{100\text{ PCF}}}\ ✓$$

NON-FLOWABLE CONDITION

IF SOLIDS DO NOT CONTAIN FREE WATER FOLLOWING HYDRATION:

$$\gamma_{equiv} = K_o\,\gamma_{solids}$$

SOLIDS NO LONGER SATURATED. MUCK AND CLAY WILL HAVE FRICTIONAL COMPONENT AND C=0 PSF. ASSUME $\phi = 30°$ AND $K_o = 0.5$.

ASSUME HYDRATED, NON-FLOWABLE SOLIDS HAVE LESSER DENSITY THAN 100 PCF (FLOWABLE) SINCE WATER CONTENT WILL BE LESS ($\gamma_{wet} = \gamma_{dry}(1+\omega)$). SINCE NO INFORMATION IS AVAILABLE ON MOISTURE CONTENT OR DENSITY FOLLOWING HYDRATION, ASSUME $\gamma_{solids} = 90$ PCF AFTER HYDRATION.

$$\gamma_{equiv} = 0.5(90) = \underline{\underline{45\text{ PCF}}}\,^*$$

* POTENTIAL LATERAL IMPACT LOADS FROM SOLIDS REMOVAL SHOULD ALSO BE ANALYZED.

SITE RESTORATION

WARZYN
ENGINEERING INC

BY DJD DATE 3-1-85 SUBJECT OMC - DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD. BY T.L. DATE 3-5-85 CONCEPT SUBMITTAL JOB NO. 1337

SITE RESTORATION

V CURING CELLS

SITE RESTORATION OF THE CURING CELLS AREA WILL OCCUR FOLLOWING REMOVAL OF ALL "FIXED" MATERIAL TO THE APPROPRIATE DISPOSAL AREA.
A GENERAL DISCUSSION OF SITE RESTORATION IS LOCATED IN THE LAGOON SITE RESTORATION SECTION. ITEMS SPECIFIC TO THE CURING CELLS ARE INCLUDED AS FOLLOWS:

B. CONTAMINATED MATERIAL REMOVAL

1. CLOSURE OF THE CURING CELLS WILL REQUIRE THE REMOVAL OF 1390 CY OF SOIL CEMENT WHICH MUST BE PLACED IN THE PARKING LOT CONTAINMENT CELL.

2. THE TOP CLAY LINER, APPROXIMATELY 2770 CY, MUST BE REMOVED AND PLACED IN THE CONTAINMENT CELL.

3. IF CONTAMINATED FLUID IS DETECTED IN THE UNDER DRAIN SYSTEM, THE GRAVEL, PIPES AND BOTTOM CLAY LINER IS ASSUMED TO BE CONTAMINATED. ADDITIONAL DISPOSAL IN THE CONTAINMENT CELL OF 2770 CY OF GRANULAR MATERIAL AND 2770 CY OF CLAY WILL BE REQUIRED.

IF THE MATERIAL IS NOT CONTAMINATED, IT WILL BE HAULED OFF SITE FOR DISPOSAL.

VI. Curing Cells

Site Restoration

B. Contaminated Material Removal

4. Handling

Material removed from the curing cell containment area (i.e. - the soil cement layer and the inner clay layer) will be considered hazardous, and will require disposal in the parking lot area containment cell. The contaminated material, assumed to be a nonflowable consistency, will be loaded into lined transport trucks at the off-site disposal staging area. All transport trucks will require decontamination at the lagoon area decontamination station prior to exiting the site. It is not expected that hazardous waste manifests and placarding have to accompany this waste going to the parking lot area containment cell.

After leaving the site it will be the contractors responsibility to comply with local truck routes. The contractor must be licensed in the State of Illinois, and comply with all applicable EPA and DOT regulations in order to transport the material on a public roadway. Reasonable steps must be taken by the contractor to ensure that no release of hazardous materials occurs during transport, and the contractor shall have an emergency spill response plan in the event of any accidental release.

MABS/BI9

VI. Curing Cells

Site Restoration

C. Decontamination of Equipment and Station Removal

Following all fixation operations, the curing cells will be removed and the area will be restored. The soil-cement layer and clay liner will be considered contaminated, and will be removed for disposal in the parking lot area. Any spill areas will also be removed for disposal in the parking lot area. During the removal of all contaminated material, the removal vehicles and associated equipment will be decontaminated at the lagoon area decontamination station prior to leaving the site.

MABS/BM2

WARZYN ENGINEERING, INC.
MADISON, WISCONSIN

I-16

BY DJD DATE 3-5-85 SUBJECT CMC - DESIGN ANALYSIS SHEET NO. 1 OF 1
CHKD. BY [illegible] DATE 3-7-85 CONCEPT SUBMITTAL JOB NO. 11837

SITE RESTORATION

VI CURING CELLS

D. FINAL GRADING

REFER TO THE SITE RESTORATION SECTION OF THE LAGOONS FOR ADDITIONAL DETAILS

E. STRUCTURE REMOVAL

THE ONLY STRUCTURE TO BE REMOVED IS THE CONCRETE DIVIDER WALLS.

ALL EQUIPMENT LEAVING THIS AREA MUST BE DECONTAMINATED.

REFER TO THE SITE RESTORATION/LAGOON SECTION FOR ADDITIONAL INFORMATION

9 18236

SITE OPERATIONS/MAINTENANCE

Operation and Maintenance Provisions

VI. Curing Cells

A. Bond Break Membrane

It is anticipated that fly-ash will be the agent used in the fixing process. Accordingly, we do not expect any interaction between the fly-ash fixed material and the bottom of the curing cells which would necessitate a bond break membrane.

MABC/BK1

Operations and Maintenance Provisions

VI. Curing Cells

B. Receive/Distribute Material from Batch Plant

The material from the batch plant (dredging material mixed with fixation agent) will be discharged to the curing cell from the common berm. A bulldozer or front-end loader will be used to distribute the material within the cell. The truck from the batch plant may drive into the cell to more evenly distribute the material. This would not be recommended for Redimix trucks which would then be leaving the site with greater decontamination requirements.

C. Load Fixed Material to Trucks

Fixed materials would be loaded into trucks by a clamshell or a large backhoe, operating from the curing cells north berm. A bulldozer or front end loader would position the material within the cell to assist the clam shell or backhoe. The clamshell/backhoe would pick-up a load from the curing cell and swing 180 degrees to drop the load into a truck located at the toe of the curing cells north berm. The clamshell/backhoe would move back and forth along the curing cells north berm to remove material from each of the 3 curing cells.

D. Transport On- and Off-Site Routing

Upon receiving a full load of fixed material the truck box would be properly secured and the truck would proceed through the decontamination station and the security control station. All documents, permits, manifests, etc. would be processed by the contractor prior to leaving the site.

Trucks for transporting fixed solids to a remote licensed landfill would be contracted to the landfill, (i.e. CECOS).

Trucks for transporting fixed solids to the parking lot containment cell may not have to be contracted to a licensed landfill operator (i.e. CECOS).

MABS/BL6

I-1

Operation and Maintenance Provisions

VI. Curing Cells

E. Decontamination of Trucks

All vehicles, equipment, and personnel that come into contact with PCB contaminated materials will require decontamination prior to leaving the site. In general, the decontamination procedures for vehicles and equipment will consist of:

1. Water and detergent wash with scrubbing to remove all sediments from the equipment. Only as much water as necessary should be used, and care must be taken to keep splashing to a minimum.

2. Water rinse.

3. Collect washing and rinse fluids and dispose of properly by discharge to Lagoon 2.

This procedure should provide sufficient decontamination for equipment exiting the site. To ensure that sufficient cleanup has taken place, periodic wipe tests should be conducted using the following procedures:

1. Apply an appropriate solvent (hexane), to a piece of 11 cm filter paper (eg. Whatman 40 ashless, or Whatman "50" smear tabs or similar).

2. The moistened filter paper, held with a pair of stainless steel forceps, is used to thoroughly swab a 100 cm^2 area, measured using a sampling template.

3. The filter paper swab is then placed in a precleaned glass jar and stored at 4°C for analysis for PCB's.

Quality assurance must be applied throughout the entire monitoring program. Blank swab samples and spiked samples will be needed to insure the accuracy of the test results.

MABS/BNO